Let's Discover Science

Book Four

David Horsburgh

Introduction

The purpose of the *Let's Discover Science* books is to give the children sufficient basic skills to learn for themselves what they want to learn. The child should, as far as possible, be given those ideas which form the basis of scientific thought. Competition and grading can well be dispensed with in a course of this nature: the children should be encouraged to cooperate with each other in experimenting and in enjoying the beauties of scientific discovery and learning from their peers should be a normal part of everyday classroom activity.

Before the child can be led to any important concepts of science, it is important to *break down* certain concepts which already, perhaps, are making their way into his mind through other aspects of his education.

The first is the idea that the textbook is some kind of divine writ, to be accepted without question, swallowed without digestion, and regurgitated in the examination.

The next: that to every question there is one correct answer and only one, correct answer, and that this correct answer must always be given in the words of the book.

The next: that every effect is due to only one cause and not, as so often happens, to a multiplicity of causes.

How can the teacher break down some of these fallacious concepts? By encouraging the child to ask questions, to conduct experiments *for himself,* and to make guesses. By giving children plenty of practice at suspending their judgment and being prepared to wait and observe rather than to jump to quick conclusions; and even by the teacher and pupils occasionally saying together, 'We don't know'; followed by, 'Let's find out'.

The five books in the series are designed to give children a number of skills and concepts. While the text deals, of course, with scientific matters, the emphasis must always be on learning the skills and concepts and not on learning the

information contained in the text.

Observing, recording, the analysis of such recordings, and the practical applications of such analyses, are all introduced from the earliest stages. In addition a number of practical skills have been taught: learning to draw, to copy and to trace; learning to use language accurately; learning to guess with reasonable accuracy; learning to work from printed instructions.

The pages of the book should form only the beginning of the child's quest for scientific knowledge. Children should be encouraged to apply the skills and concepts they acquire from the book to every aspect of their environment and life.

A few notes for the teacher with regard to certain pages of the text have been printed at the back of the book.

David Horsburgh

Notes for the Teacher

(Notes are only given for those pages where some difficulty may be found, either in the interpretation of the page or in the work preceding or following the work of the text.)

Pages 1-5: These pages contain pictures which are designed to remind the children of some of the work and experiments which have been covered in the first three books of the series. If the children have not in fact used Books 1-3, it would be useful if you could have at least one copy of each of these books in the classroom, so that you can find out what experiments the pictures refer to. One possible way of revising is to ask children to tell you what they see in any particular picture, and then to describe the work which it illustrates.

Page 6: All these words have been used in Books 1-3 and it should be possible for children to test themselves in the way suggested on the page before you ask them questions about individual words.

Page 7: If possible show the children a thermometer and let them see the mercury rising when the thermometer is in water which is slowly being heated.

Page 8: Perhaps the children can be asked to bring old cycle valves or the valves tised in motor-car tires to the class.

Page 12: It is not necessary for every child in the class to make a hectograph: perhaps they can make them in groups. It is particularly important to get the children to think about the various ways in which a hectograph can be used. They can discuss these ideas in class.

Page 19: Perhaps not all the children in the class will be able to bring batteries to the class, but most of them will be able to find used ones. Perhaps you can cut open one of these old batteries (a messy business) so that the children see what they contain.

Page 20: Children should be encouraged to collect as many leaves as possible. Perhaps you can arrange a class exhibition, or, better still, a class exhibition of pages done by individual children containing pressings or drawings. The children can also use some of the methods shown on page 21.

Page 22: It is desirable but not necessary for every child to make a box. Children can equally well make them in groups.

Page 24: Group work, with individual recordings of the results.

Page 25: The material for the friction toy need not be pottery clay; ordinary mud will do, provided it is given time to harden,

Page 28: You may have to help children to find the blind spot.

Page 31: You will notice that the illustration of the tin with holes in it does not show how the water comes out of the holes. It is important that the children carry out the experiment themselves (in groups) and then draw the results.

Page 35: It is very important that children should get into the habit of doing some of their thinking with pencils in their hands. The object of the illustrations on pages 36 and 37 is to give them an idea of the way in which designers work. Designers draw things, write instructions to themselves, cross them out and write new suggestions, and so on. It is essential to give children the idea that finished or careful drawings are not needed in the early stages of designing anything. Detailed drawings, to scale and with dimensions added, form the later stages of development.

Pages 36-37: There is plenty of work for the children to do on these pages— copying, commenting, and perhaps expanding some of the ideas shown.

Page 39: Experiments can be carried out in groups and the results noted individually.

Page 40: Not very much information has been given and you can supplement it if necessary. One way of doing this is by getting the children to try to formulate questions on their own; .this is perhaps more useful than your giving them additional information.

Page 43: Children can do the modeling either individually or in groups. One group, for example, could make a set of birds, or bones, or solids, etc. Finally all the models in the class could be made into a little exhibition. Explain to children when they have read pages 42-43 that they should not think that the subject of paper machie" is a closed one. There will be many instances in Book 4, and also in Book 5, when they can use this technique for making further models,

Page 51: Children can make the *Rocket* individually or in groups. Perhaps, when groups have made models, individuals will want to follow suit.

Page 64: Group work.

Page 71: Children can do these experiments in groups, and report their findings to the class.

Page 73: Perhaps children can be asked to suggest more words which may have come from Greek or Latin, or words which scientists use in a way different from the normal use.

Page 78: If necessary children can work in pairs to make their sets of punched cards.

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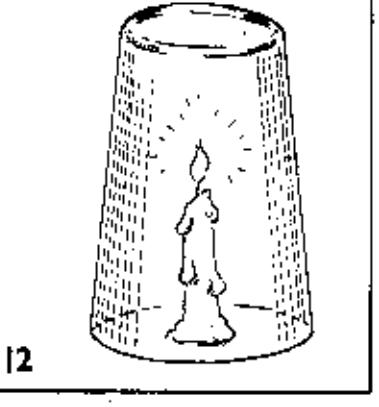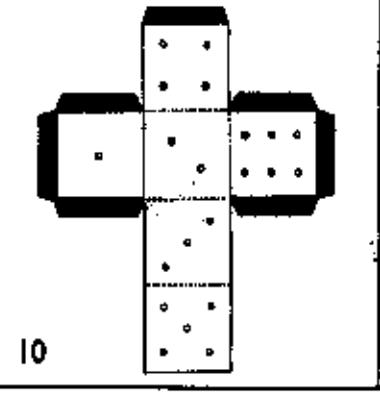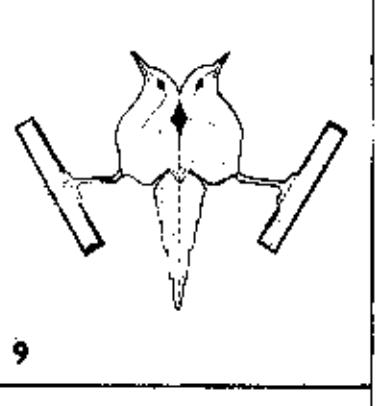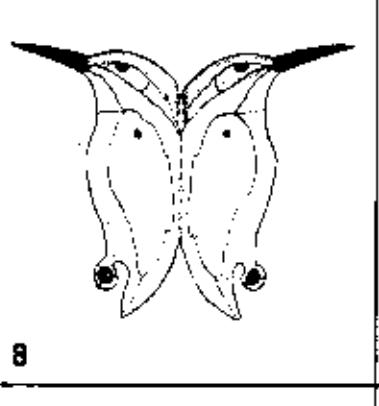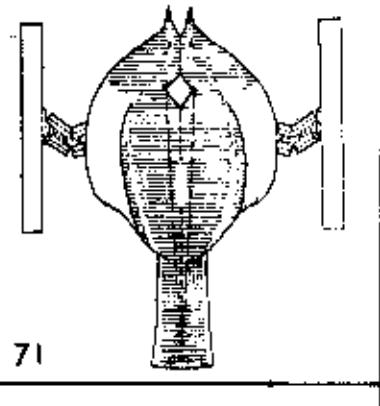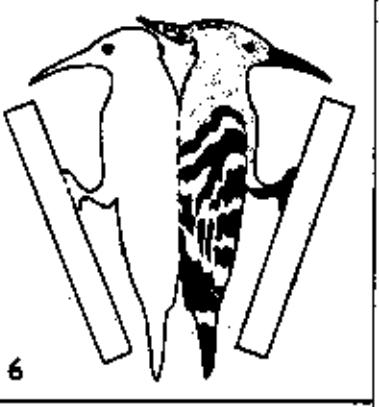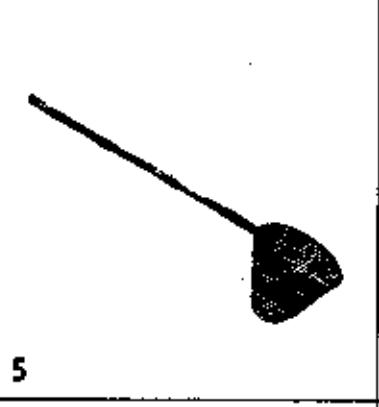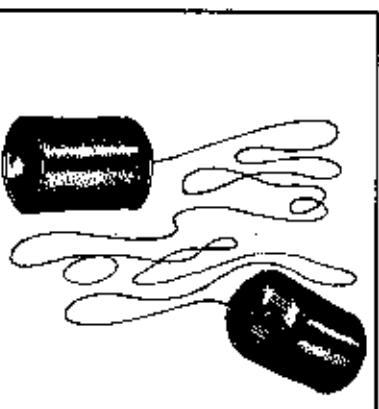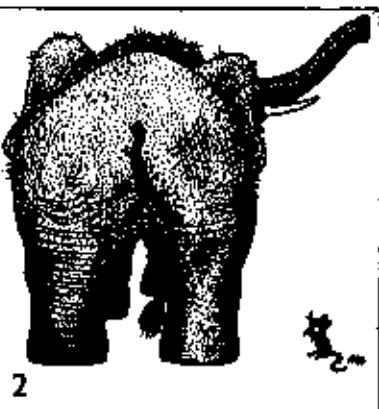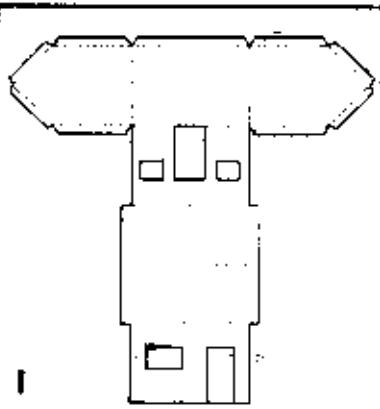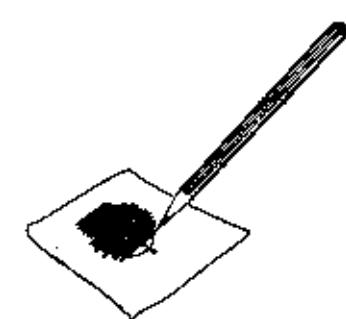
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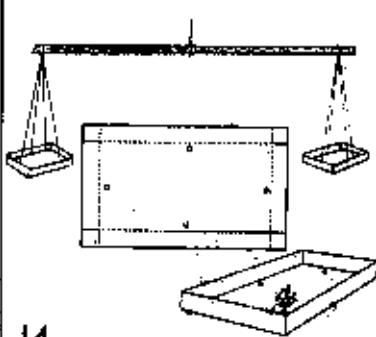
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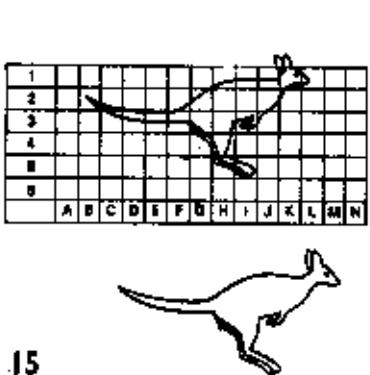
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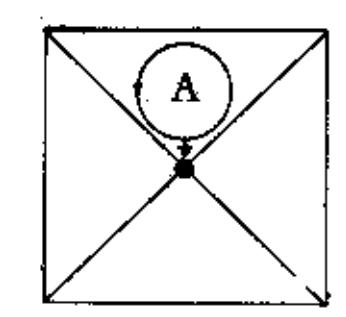
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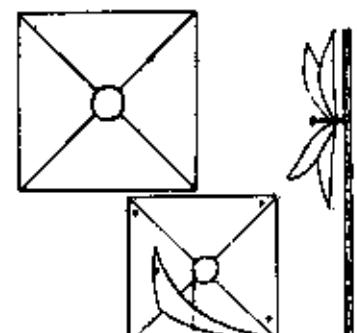
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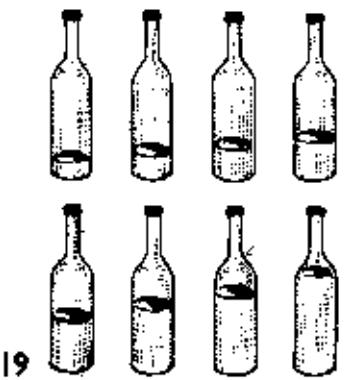
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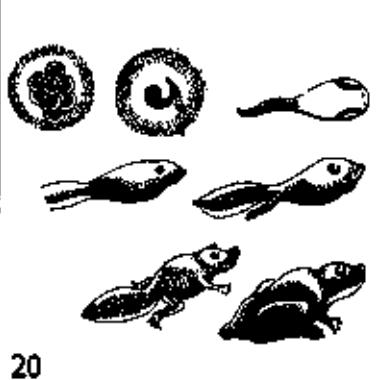
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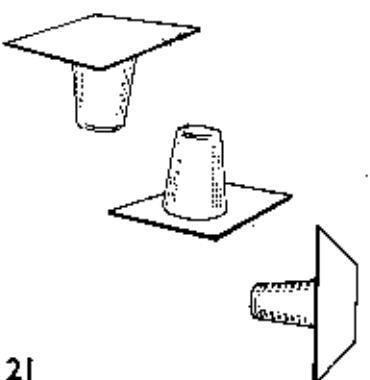
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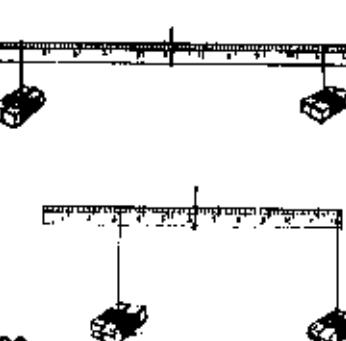
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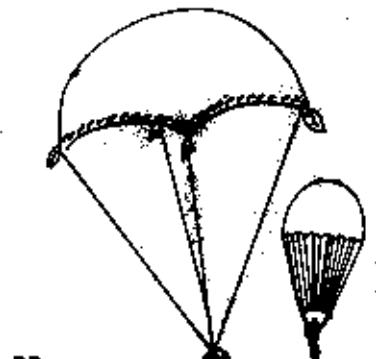
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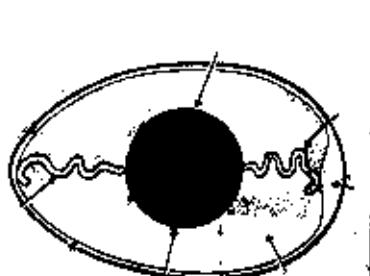
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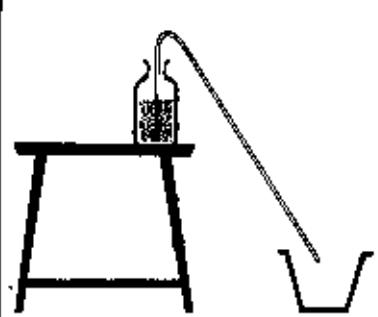
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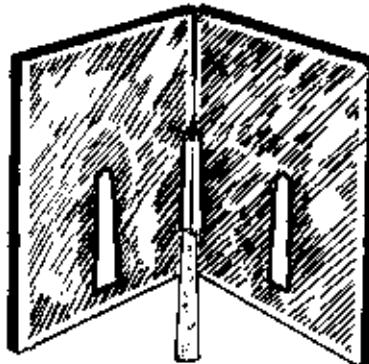
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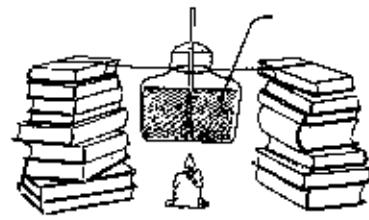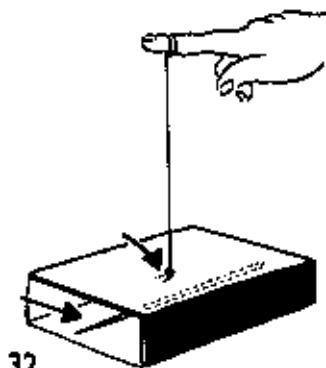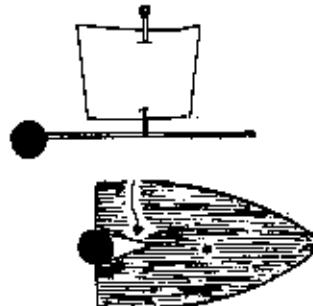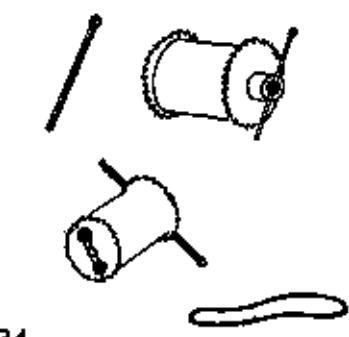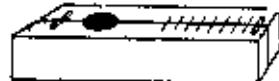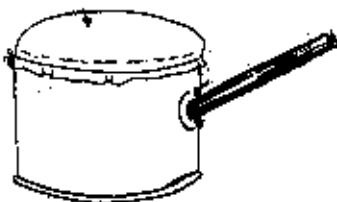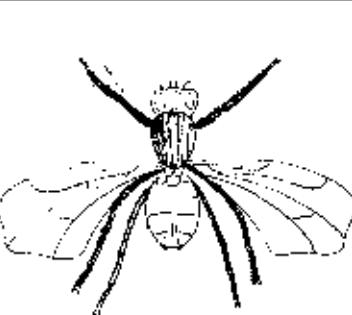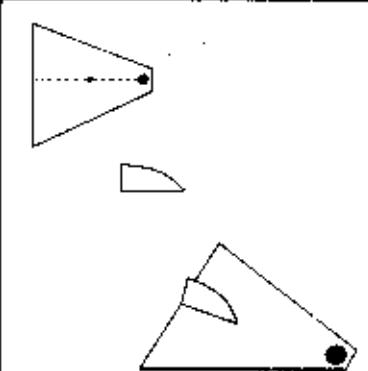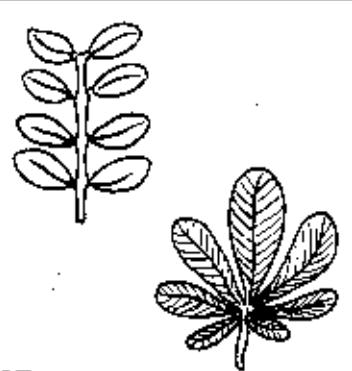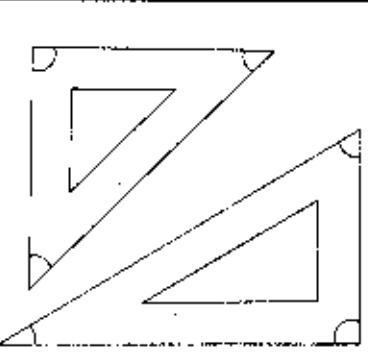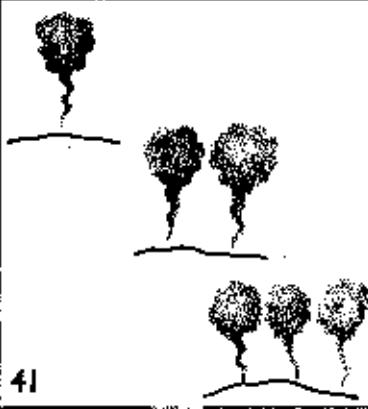
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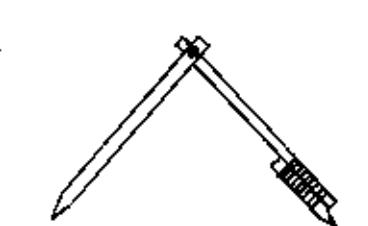
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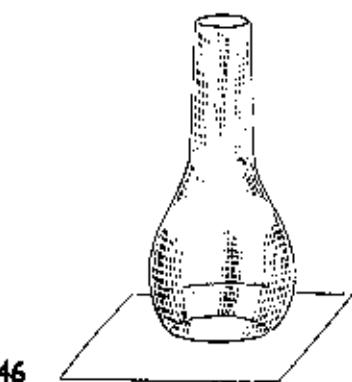
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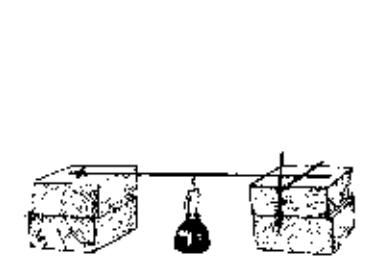
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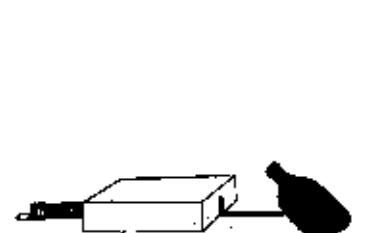
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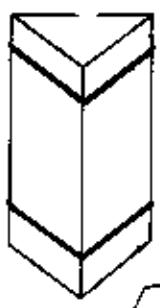
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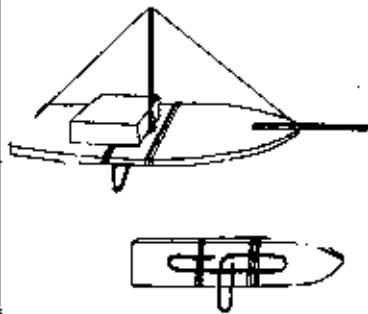
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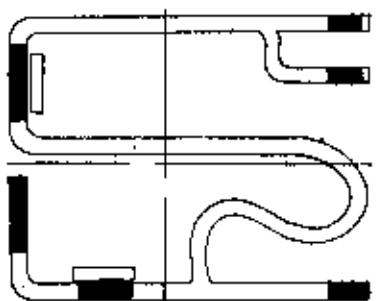
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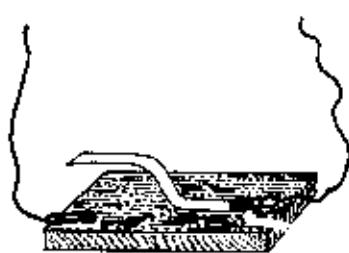
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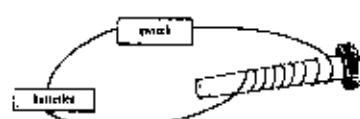
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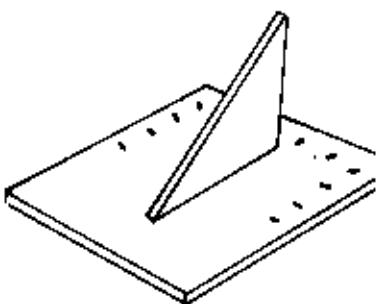
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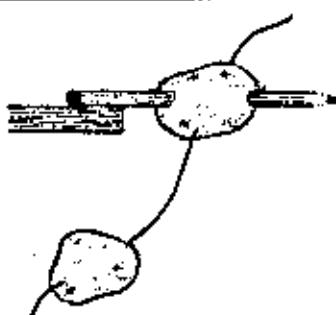
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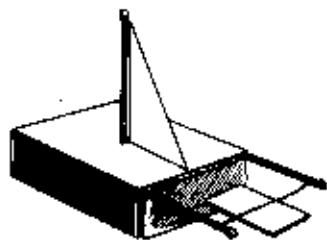
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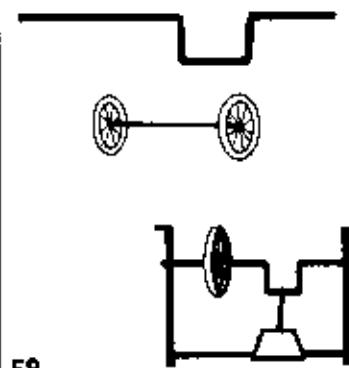
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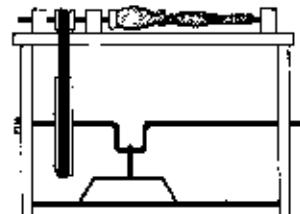
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Revision

All the words in the lists below have been used in books 1-3, and you should know them. The best way of finding out whether you know them is to ask yourself:

A. Can I *explain* the word? e.g.

   Expand means *to get bigger*, and

B. Can I *use* the word in a sentence? e.g.

   Metal *expands* when it is heated.

Here are the words: You will need to know them when you read this book:

leaf	invisible	effect	axle
stalk	resistance	smoke signal	shaft
petal	syphon	set square	crank
rust	compressed	protractor	treadle
lever	mirror	compasses	fly wheel
fulcrum	reflection	dimension	sepal
vocal chords	expand	plan	stamen
vibrate	magnet	pressure	pollen
pendulum	compass	indicator	pistil
symbol	shadow	acid	ovary
Morse code	eidophone	contract	stigma
pulley	friction	transparent	
gear	compound leaf	kaleidoscope	
dissolve	filter	switch	
boil	substance	coil	
machine	property	sundial	

6

Temperature

Look at your ruler. We measure lengths in centimetres and millimetres, and the small lines on your ruler show the length of a centimetre and a millimetre.

We measure heat in **degrees.**

Very hot (the temperature of boiling water) is 100 degrees.

Very cold (the temperature of ice) is 0 (nought or zero) degrees.

We write degrees like this: 0° 25° 100°.

The small circle stands for the word 'degrees.'

We measure heat with a

thermometer.

A thermometer is a glass tube, closed at both ends. Inside it there is some liquid called **mercury.** When the temperature rises, the mercury expands up the tube. We can mark the tube and see where the level of the mercury is. Ask your teacher to show you a thermometer. Fill in the scale in the illustration, between 0° and 100°. Make a temperature chart, and put in it the temperature every day at mid-day. Try to guess the temperature at night. If you can get a newspaper you may find the temperature in all parts of India.

What temperature is shown in the thermometer on this page?
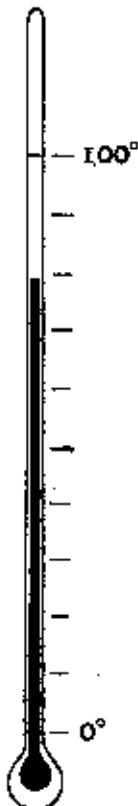
Valves

Do you know the word **flow**? It means *to move,* and scientists use it about liquids and gases and heat. They say, for example:

Water *flows* down a pipe.

Heat *flows* along a piece of wire.

Sometimes we want water or air to flow in one direction only. We use a **valve.** Here is a simple valve. It consists of a tube, closed at one end with a plate with a hole in it. **A** shows a picture of the tube, **B** shows what it is like inside. There is a metal ball inside, nearly as big as the tube but bigger than the hole. If you push the tube down into some water, the water pushes up the ball and enters the tube. If you now lift the tube, the ball is pressed into the hole by the water, and the water remains in the tube. If we pump up a cycle tyre, we want air to *flow* into the tube, but we don't want it to *flow* out again. We use a **valve.** The rubber over the tube opens when we pump air in at **A,** but closes when we stop pumping.
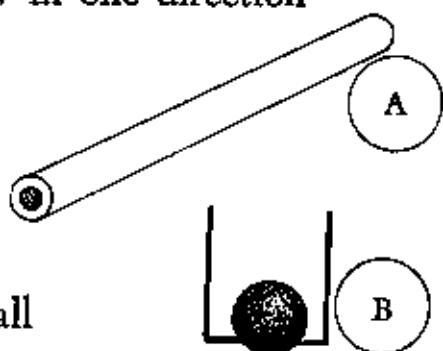
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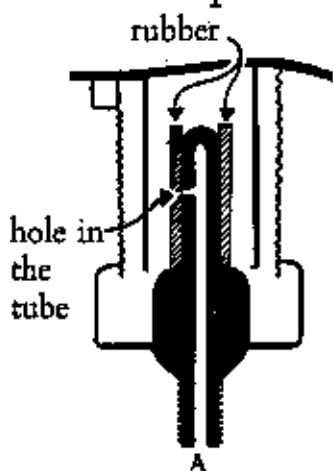
Valves and Pumps

Here is something which could be used for lifting water. The rubber sits over the hole at the bottom of the tin and is held in place by a springy circle of wire on top of it. If you push the tin into some water, the water will push up the flap of rubber and enter the tin. When you pull the tin out the rubber will close over the hole and hold the water in the tin.

string

tin

small hole in the centre of the bottom

circle cut from inner tube rubber

x
y

centre cut stops at x - y
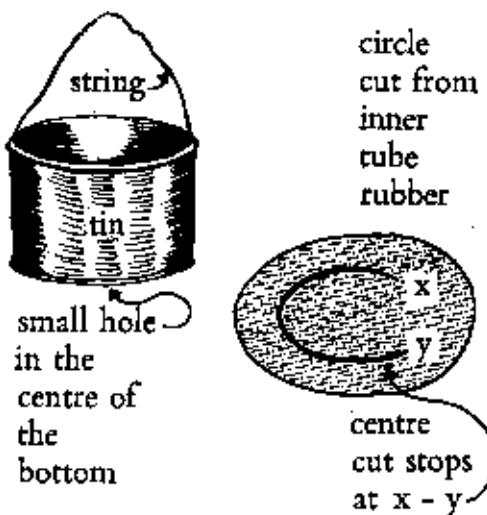
A Lift Pump

Find two corks and a length of pipe about 45 cm long. One cork **A** should have one hole in it, big enough to take a drinking straw. On top of cork **A** fit a flap of rubber, with a small nail or a pin. Cork **A** should be a tight fit in the bottom of the pipe. Cork **B** is the piston, and has 3 holes in it. The middle one should be big enough to take a long bolt. Over the cork fit another rubber flap, and then fasten the nut. What happens when you push the piston down? What happens when you pull the piston up? You fit a *wheel* on top of the pump to pull the piston up and down. Draw the wheel.

bolt with 2 nuts

rubber flaps

cork
B (piston)

holes in cork

cork **A**

drinking straw

water
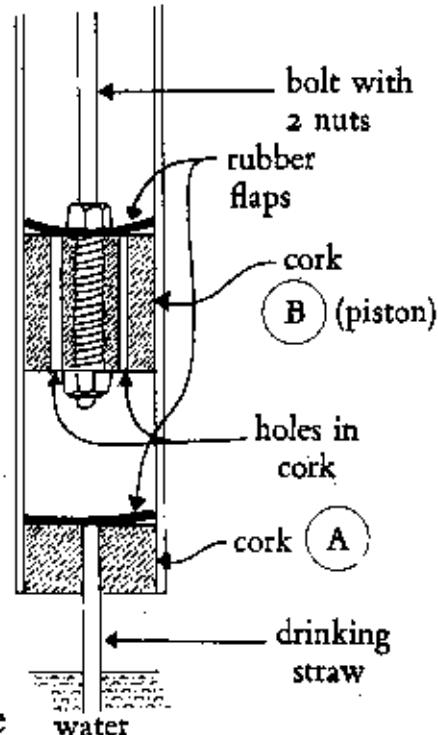
Muscles and Bones

Here is a picture of an arm.
In the picture muscle is shown
like this:

and bone like this:
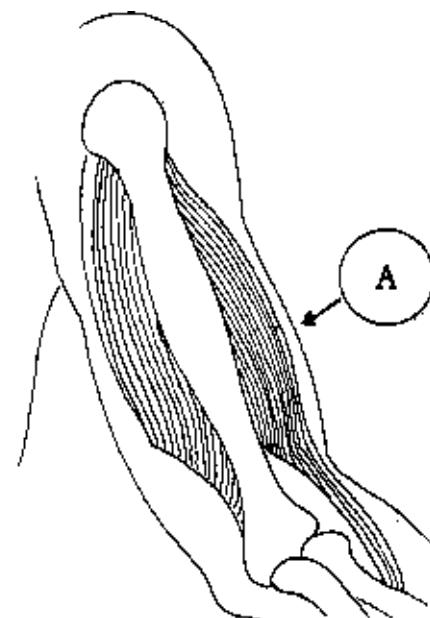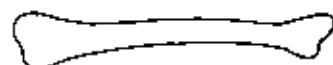
Can you feel the bone in your elbow? Hold your arm
out straight and put one hand at **A**. Now bend your
arm. What happens? Can you feel the muscle? It is
now like this inside your arm:
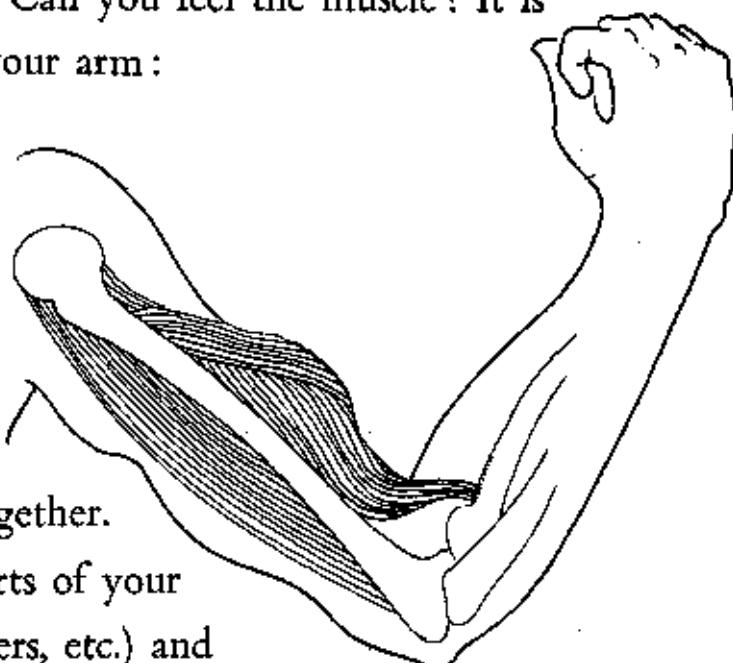
The muscles of our
body pull the bones
of our body closer together.
Try moving other parts of your
body (legs, head, fingers, etc.) and
put your finger on the muscles
as they move. Try to find some
bones of animals or birds and draw them in your books.

The Skeleton

skull

lower jaw

shoulder bones

breast bone

ribs

back vertebrae

elbow

hip bone

thigh bone

knee

hip joint

ankle

toes
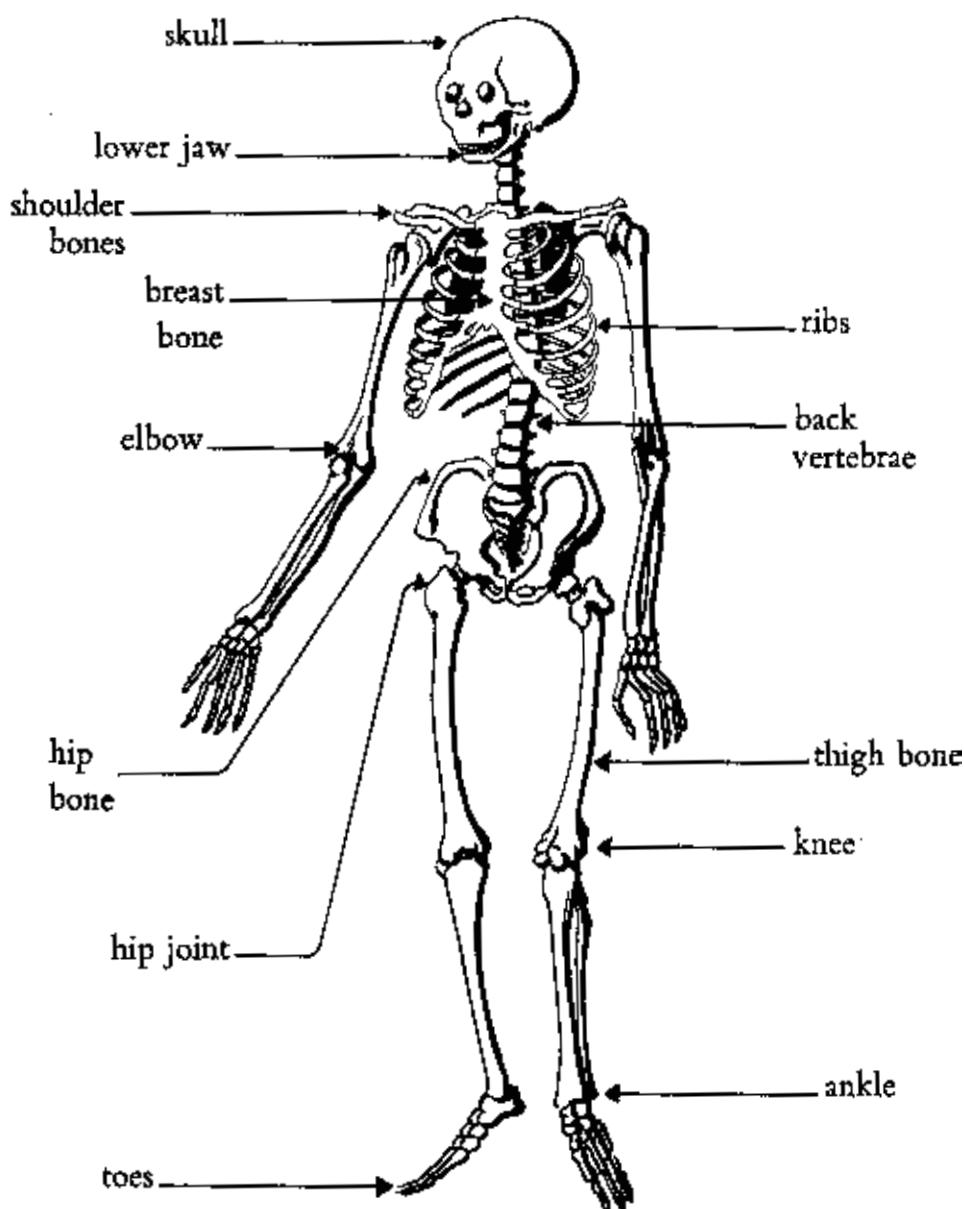
Here are some of the bones in your body. Trace the picture into your exercise books, and label the parts. Can you feel all the bones mentioned? How many ribs have you got? Feel them and see. Do bones grow?

A Hectograph

The word **hectograph** comes from two Greek words:

hekaton means *a hundred*

and *graphein* means *to write.*

Do you know any other words ending in *graph*? Do they have anything to do with writing?

A **hectograph** is something which helps you to make copies of what you have written. This is what you need:

1/2 a litre of **glycerine**

4 large spoons of **gelatine**

3 large spoons of **sugar**

1 flat dish of tin, or aluminium
(30 cm by 20 cm : 2 cm deep)

Gelatine is used for making jellies; you can buy it at a food store. Glycerine you can buy at any chemist's shop.

Dissolve the gelatine in a glass of cold water. Leave it overnight. In the morning mix in the glycerine and sugar. Heat over a gentle fire. Raise the heat slowly until it boils, stirring it all the time. Let it boil for about 5 minutes. Then pour it into the flat dish and let it set. Your hectograph is ready.

A Hectograph

shallow tin

jelly
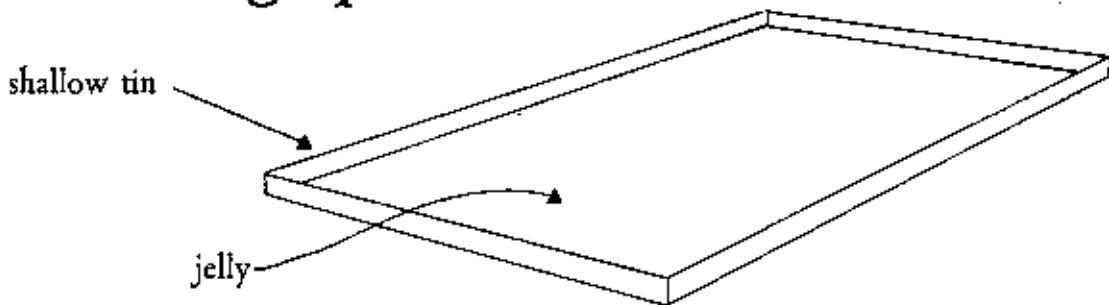
Now you will need some ink. You will need some spirit ink;
you can either make it yourself, with a little spirit and aniline
dye, or you can buy it at a stationery shop. Now take a piece
of paper and write on it whatever you want to have copies of.
When the ink is dry place the paper face downwards on the
jelly. Press it smooth, and leave it for 5 minutes. Remove it and
put a clean sheet of paper on top, press down, and remove your
first copy. Continue in this way with other copies.

What to do with a hectograph?

You can make copies of notes and summaries for the whole
class. (This will save time in class as the teacher won't have to
dictate them.)

You can run a class magazine.

Every member of the class can produce a page on a particular
plant, with diagrams, labels and descriptions: then each page can
be hectrographed (or duplicated) and every one in the class will
have a complete book of plants. You can think of more ideas
of your own.

13

Weighing an Elephant
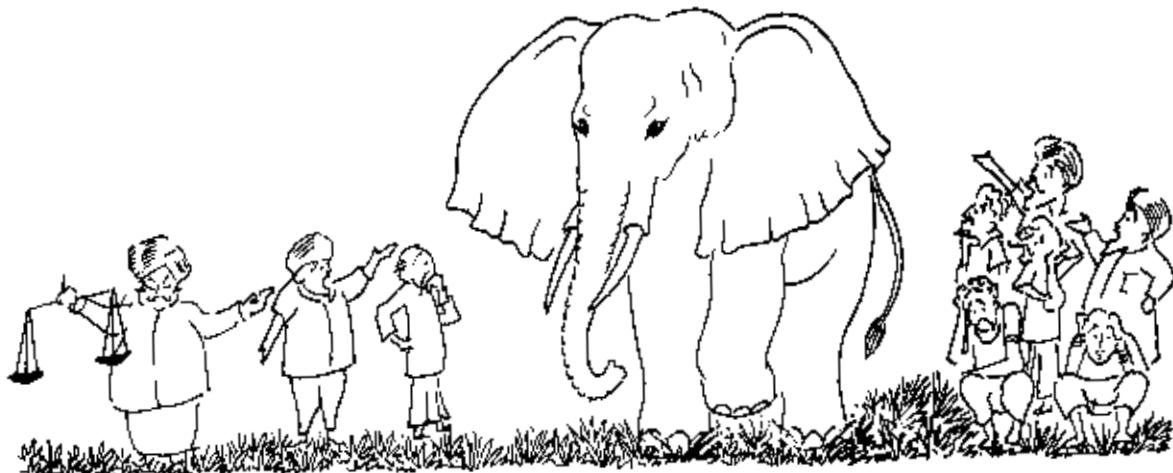
Many years ago there lived a king. He had an enormous elephant, and he wanted to weigh it. He called all his wise men together, but no one had a weighing machine big enough. But at last two of his wise men hit on a plan; each plan was different.

A   What were the two plans? Both were correct ways of weighing the elephant, but the elephant was happy about one way, and not about the other.

Write out any ways you can think of, with diagrams if necessary. Then read the answer.

The first man's plan was this: cut the elephant up into small pieces, and weigh each piece. This was the plan the elephant did not like. The second plan was this: put the elephant in a boat, and mark the side of the boat at the level of the water. Take the elephant out, and put stones in the boat until the same level is reached. Weigh the stones. The elephant approved of this plan.

Don't read ← this until you have written Ⓐ

Answer

Volumes

Do you know the word **volume**? It means the space filled up
by something. A fat boy next to you on the bench takes up
more space than a thin one; his volume is greater. If we want
to find the volume
of this brick, we
multiply the length
by the width, and
then multiply that
by the height.

width 5 inches

height 2 inches

length 10 inches
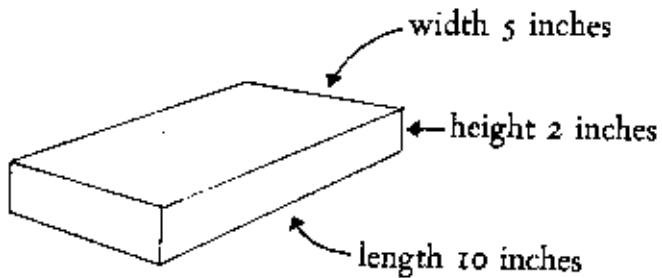
That is 10×5 = 50.

50×2 = 100.

The answer is 100 **cubic inches.**

Finding the volume of things is easy with shapes which are regular,
such as bricks, boxes, etc. How do you
find the volume of a stone like this:
Think of the elephant on page 14.
That was a way of finding *the weight.*
How would you find the volume?

←about 15 cm→

Draw a diagram, and write a description of your plan for
finding the volume of the stone.

What difficulties are there in carrying out the plan? Your plan
must be a *practical* one: that is, it must be one you can carry out.
Think of the problems first; then try to solve them; then write
your plan; then carry it out.

Insects

Do you remember the picture of the fly in Book 3 (page 30)?
Here is the same picture, next to a picture of a mosquito.
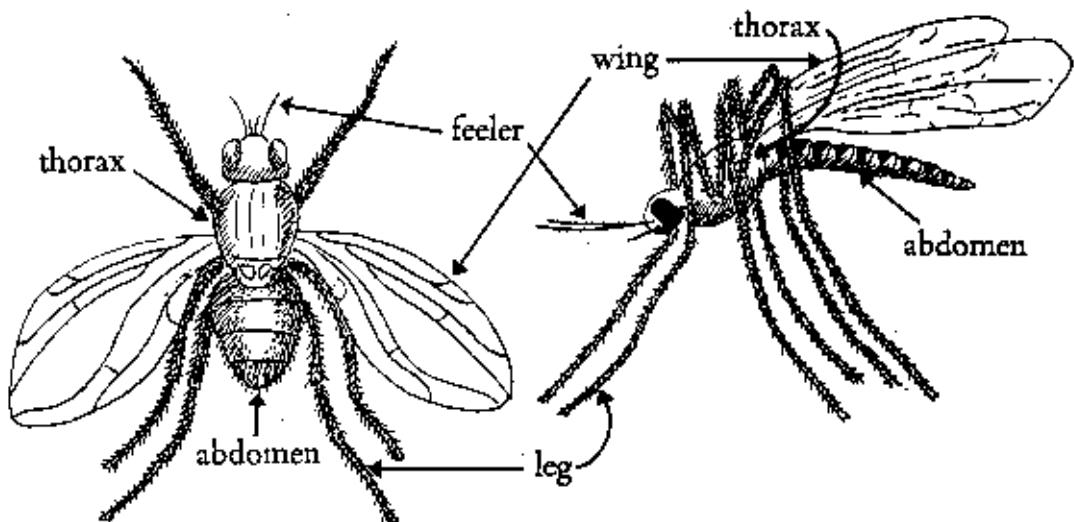
In most insects the life-cycle is as follows:

egg ———→ larva ———→ pupa ———→ full-size insect

Each stage is different. Small mosquitoes do not grow into large
(adult) mosquitoes. The life-cycle of mosquitoes is like this:

eggs	larva	pupa	adult
(hundreds			mosquito
of them)			
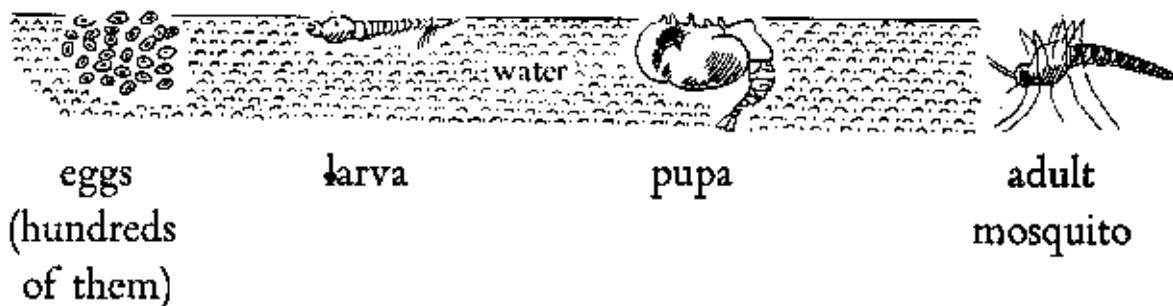
Notice that eggs, larva and pupa are all in water.

No water — no mosquitoes.

Insects

Try to find some more insects. Study them carefully;
try to make a drawing of each. Compare your drawing with
those of the fly and the mosquito.
Then look at all your drawings and try to answer these questions:

How many legs do insects have?

Can they all fly?

Do they all lay eggs?

Do they all have a head, a thorax and an abdomen?

Do they grow from babies to adults?

How many legs do they have?

How many feelers do they have?

Here are some insects you can easily catch. Put them under a
glass tumbler; study them carefully; then draw them and
write about them:

a fly, a mosquito, a wasp, a cockroach,
a mosquito, a butterfly, a moth, an ant,
an earwig.

There are probably 5 lakhs of different insects in the world.
Are insects helpful to us or not?

Electricity

Amber is something like yellow stone. It is formed from the resin of trees which, over thousands of years, has changed to stone. It is used for ornaments. Many years ago people noticed that if amber ornaments rubbed against cloth, the amber *attracted* hair and feathers. Later on, when men discovered *electricity*, they called it by that name because *elektron* in Greek means *amber*.

Friction

Do you remember that friction means rubbing? You can produce electricity by friction.

1. Rub a piece of brown paper (it must be dry) with a brush, a number of times. Lift the paper carefully by one end, and hold it over your head. Your hair will stand up. The electricity has attracted it.

2. Rub a comb, or a glass tube, or a piece of wax, or a plastic fountain pen, with fur or silk or flannel. See if they pick up small pieces of paper.

3. Put a piece of glass over two books and cut some paper figures and put them under the glass. Rub the glass with silk or flannel. What happens to the figures?

18
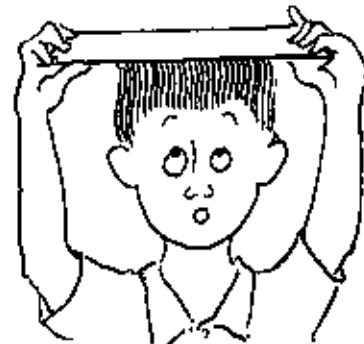
Electricity

You can see from the experiments on page 18 that electricity can be produced by friction. But this is not a very convenient way of producing it. We usually get electricity from

cells

accumulators

generators .

Cells are, for example, the cells you buy for your torch.

An accumulator stores electricity : for example, a car battery.

A generator produces electricity : it may be a small **dynamo** on your bicycle, or a huge generator in a power station which supplies the whole town with electricity.

Make a chart showing all the *uses* of electricity you can think of, and the things which use electricity.

Headings	Lighting	Moving .... (things which move from place to place)
Lifting	**Sound**	**Moving** .... (things which do not move from place to place, but have moving parts)
Heating	**Cooling**	**Cooking**

and more headings of your own. Give as many examples under each heading as you can.

19

Botany

Botany is the science which deals with plants. You have already studied some Botany in Book 3. Do you remember these words: sepal, stamen, pistil, stigma, and ovary? Many plants have fruits. The ovary of the flower turns into a fruit, and in the fruit are the seeds. Seeds grow into new plants.

Make a list of some of the fruits of plants you know, and draw the seeds.

Here are some to begin with:

orange, bean, apple, ladies finger, grass, rose.

Do you keep a leaf book? With pressings or rubbings of leaves? Here are some groups of leaves. See how many leaves from each group you can find.
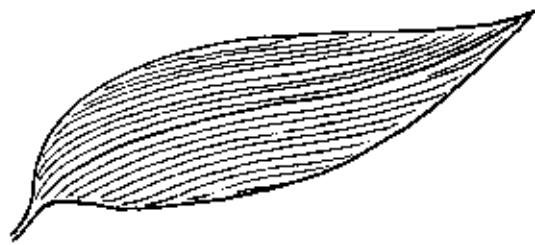
net-veined   parallel-veined

| alternate on the stem | opposite on the stem | whorls round the stem | spiral round the stem |
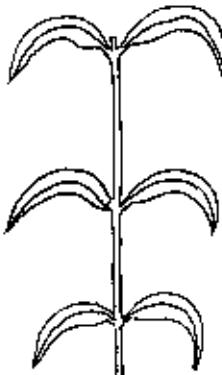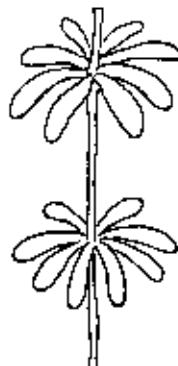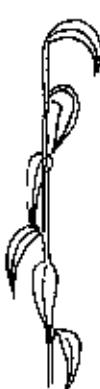
Botany

In your leaf book you can make some silhouettes of leaves. A silhouette is the shape made by a shadow.

shadow or silhouette   leaf   torch
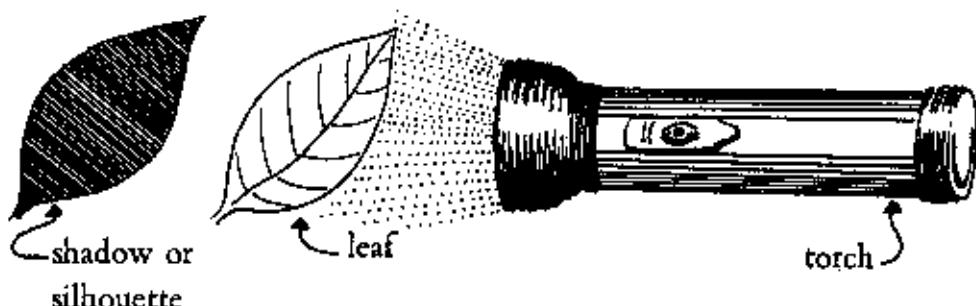
Put the leaf on a clean piece of paper. Take a small, stiff brush (an old tooth brush will do), dip it in paint, and scratch the bristles of your brush with your finger. Spots of paint will fly on to the paper, but the paper under the leaf will not be touched, and you will have a white silhouette. Cut the paper into a neat rectangle and stick it into your leaf book.
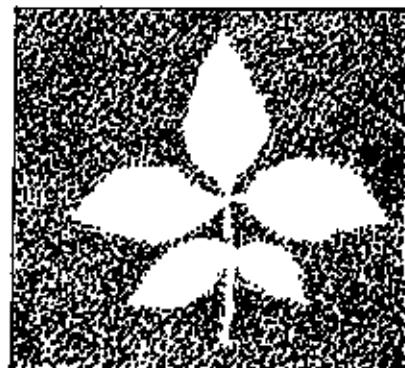
A Flower List

Make lists of all the flowers you know or can find. List them under these headings. Note whether or not you have actually seen them.

|	
Garden flowers	**Wild flowers**
Vegetable flowers	**Field crop flowers**
Flowers on trees	**Flowers in pictures**
Foreign flowers	(poems, stories, books)

Light

Do you remember what you learned in Book 3 about rays of light? *They travel in straight lines.*

A smoke box

You need a box (preferably of wood, but cardboard will do) about 50 cm long, 30 cm wide and 20 cm high. Put glass on one long side. Put cloth on the other side, fixed at the top and not at the bottom, like a curtain. Paint the inside of the box black. At one *end* cut a hole 10 cm by 10 cm. You can cover this opening with different kinds of cards like this:
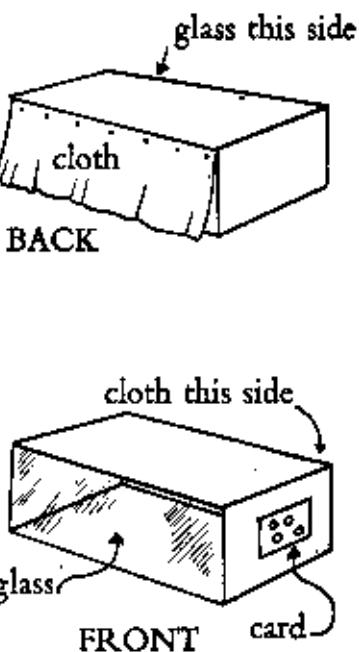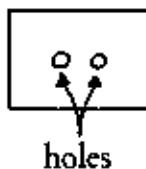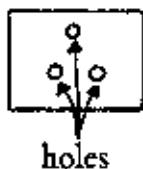
Fix one of the cards over the opening with drawing pins. Now fill the box with smoke (burning charcoal in a tin lid with a few drops of water on it: or mombattis: or damp brown paper smouldering in a tin). Shine a torch through the holes in the card and watch the rays through the glass. What happens if you put a mirror like this in the box? What happens if you put a piece of plastic in place of the mirror: or a piece of cardboard?

22
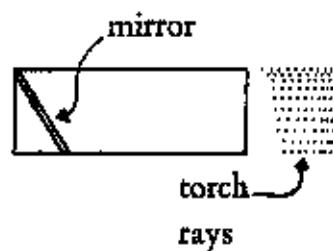
Smoke Rings

Make another kind of smoke box. This box will blow beautiful rings of smoke. Cut a hole in one end of the box and fix cloth over the other end. Leave the bottom of the cloth loose so that you can put in the smoke (see page 22). When the smoke is in the box, make the cloth tight under the bottom of the box, and then tap the cloth smartly with your finger. Rings of smoke will emerge* from the hole.
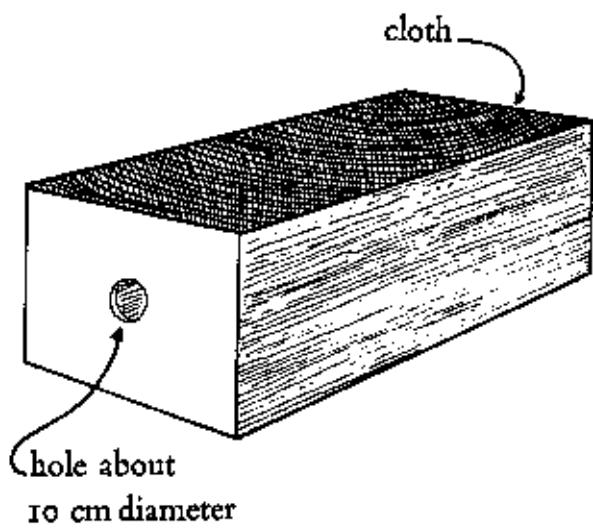
cloth

hole about
10 cm diameter

Watch the rings carefully.

> Are they all the same size?
>
> Can you cut them with a knife?
>
> Can you make one ring hit another?

If there were no smoke in the box would there be any rings?

Yes, there would. But you couldn't see them. How long do the rings last? Can you blow a soap bubble through one of the rings?

* *Emerge* means *come out.*

23

Friction

Friction means *rubbing*. Do you remember the work on friction you did in Book 3 ? Matchboxes sliding down rough and smooth surfaces ?

In many ways scientists want to overcome* friction, because friction stops machines from working as well as they could.

Take a box and fill it with sand :
put a piece of string on the
front. (An empty chalk box
will do well.)
Now pull it over some sand.
Now pull it along over some
smooth wood.
Now try with grease on the
wood.
Now put 3 or 4 pencils under
the box.
Now take two tins, and put
them on top of each other.
Press on the top tin and at
the same time try to turn it.
Now put 10 or 12 marbles on
the rim of the bottom tin. Put
the other tin on top. Now press
and turn. You can stand on the
top tin and it will still go round.
You have made a ball-bearing.
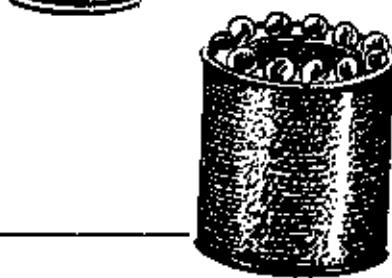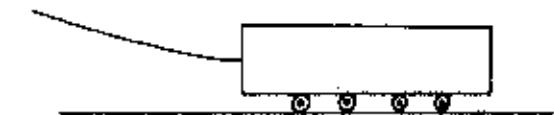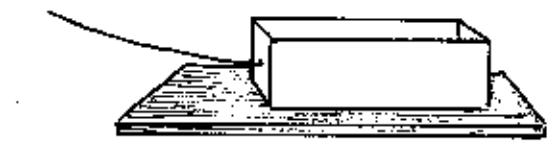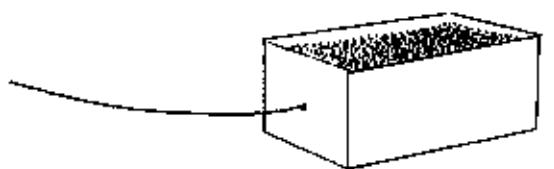
* *Overcome* means *conquer*.

24

Friction

What did you learn from your experiments on page 24 ?

MOST FRICTION ⎯⎯⎯⎯⎯➤   rough surfaces
⎮   smooth surfaces

LESS FRICTION ⎯⎯⎯⎯➤   greasy surfaces
⎮   rollers

LEAST FRICTION ⎯⎯⎯➤   balls
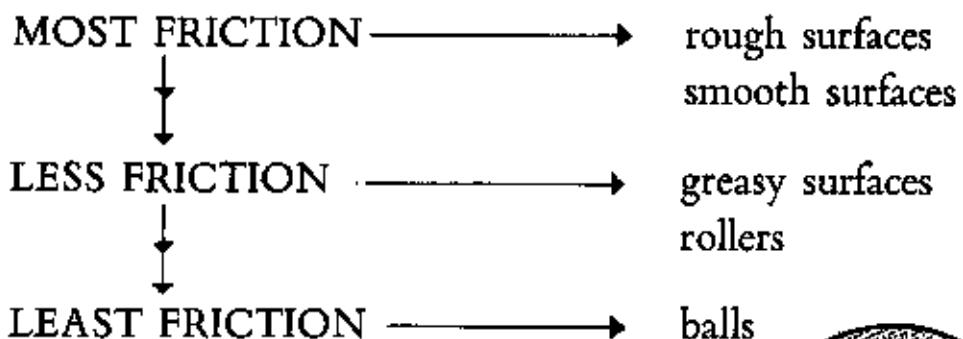
There are a number of ball-bearings in a cycle.
The bearing moves on steel balls. The inner
ring 🌙 is fixed tightly to the axle. The outer
ring 🌙 is fixed tightly to the wheel. The
wheel moves round the axle on the steel balls. See if you can
find machines which use ball-bearings. Old spare-part shops or
cycle shops have plenty.
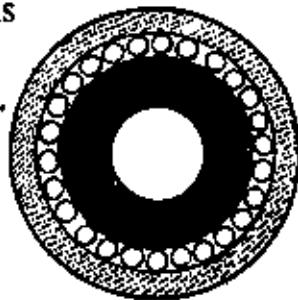
A friction toy

Here is a toy you can make which works by
friction. Make some clay with mud and water.
Make an oblong lump about 10 cm by 5 cm
by 3 cm. When the clay is fairly dry, take a
pencil and push it through the top at an angle,
as shown. Then from the bottom, again at an
angle, so that the holes meet. Put a piece of
string through the hole. When you hold the string tight the
block won't move; when you hold the string loosely it slides
down the string.

25

Drawing

Very often engineers need diagrams of machines. You already know the difference between

a picture   and   a plan.
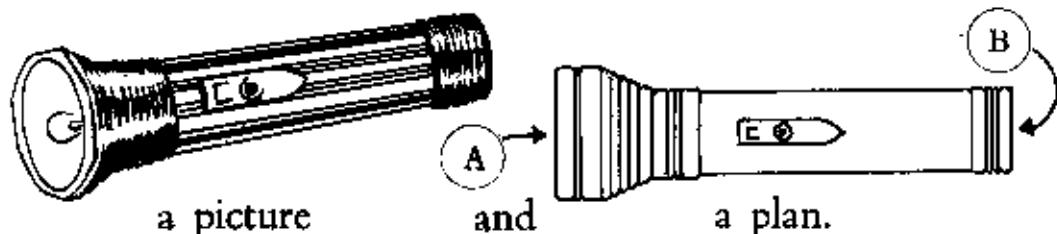
A plan is a picture of a thing seen from above. Here are two more plans of the torch:
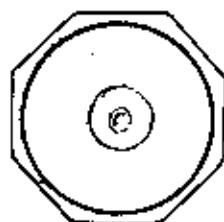

view from A above   view from B above

Sometimes engineers want to see what a thing looks like inside. They imagine they are cutting the thing in half:

Imagine a coconut cut in half.

We could then make a plan of half the coconut which would look like this:
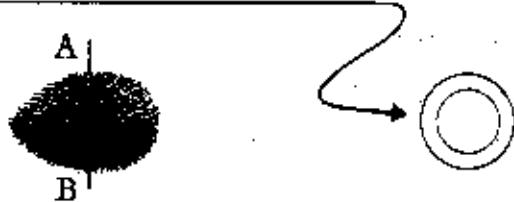
A plan of something cut in half is called a section.

A—B shows where we cut the thing.

Drawing

A **section** of a pencil ⟶ ⊙

A **section** of a football ⟶ ◯

A **section** of a bottle ⟶

Quite often engineers put **shading** on a section to make the meaning clearer. For example,

a section of a metal tube ⟶ ◎
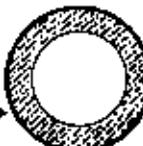
Make section drawings of the following: the line A — B shows where each should be cut. (1. has been done for you.)

1

A ⟋⟍ B

2 A ⟋ B

3 A ▮ B

4 A 🐘 B

5 A ☕ B

6 A 🌳 B
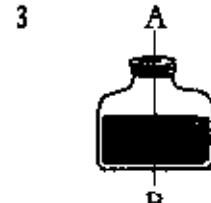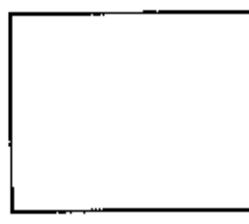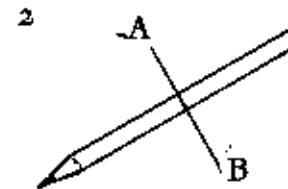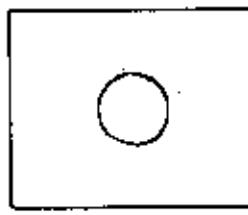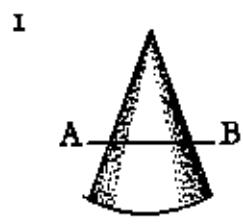
And two more of your own:

7

8
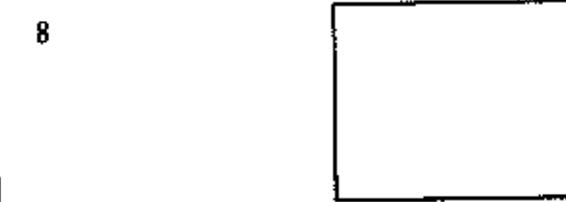
The Eye

Do you remember what you learnt about the five senses in Book 3 ? Here are two drawings of the human eye:
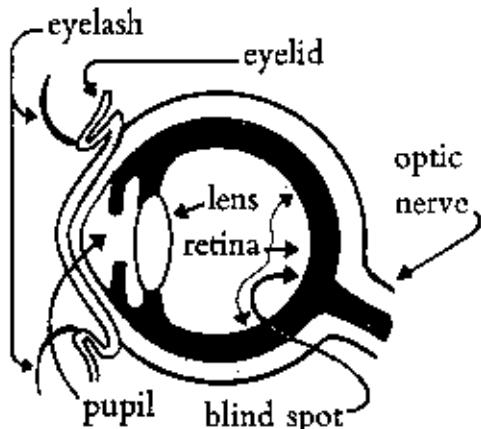
Section of the human eye
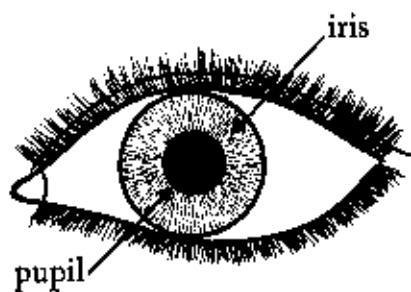
View of the eye from the front

Look carefully at your eyes in a mirror. Can you count your eyelashes? If you look out at the night sky in the dark, and then come into the light, what happens to the pupil and iris: do they change in shape? Look carefully at a cat's eyes: are they like yours or different?

The blind spot

Cover your right eye with one hand and look at the ✚ and ● below: ●   ✚

Now move the book away from you. The spot will suddenly disappear when it falls on the blind spot in your retina. There is no retina where the optic nerve enters the eye. Copy the drawings into your books.

The Ear

Do you remember what you learnt about the human eye on page 28 ?

Here is a diagram of the human ear:
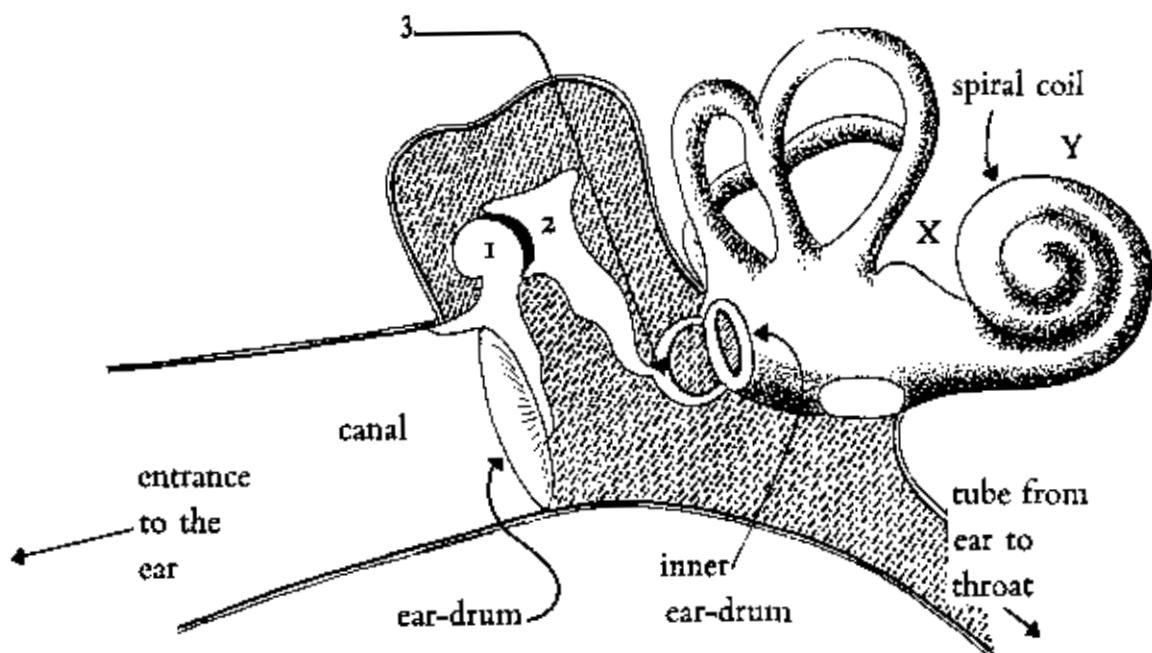
This shows part of the ear which you cannot see from outside. Sounds come from outside through the entrance of the ear, and pass along the canal to the ear-drum. From here they pass to the inner ear-drum through three bones:

        1. the hammer

        2. the anvil

        3. the stirrup

The sounds then pass into the spiral coil (called cochlea) and then pass through the nerves to the brain (at Y).

The nerves at X pass messages to the brain about our sense of balance.

Copy this drawing into your exercise books.

Lots of Senses

You learnt something about the eye and the ear on pages 28 and 29. Sight and hearing are the two most important senses: most of what we know about the world comes from these two senses.

Smell

We smell with our noses. In our *nostrils* are some tiny sensitive cells called *smelling patches*.

Taste

We taste with our tongues. At the back of our tongues are another group of sensitive cells called *taste-buds*. We cannot taste from a distance. The thing to be tasted has to contact, or touch, our taste-buds.

Touch

All over our skin we have another set of sensitive cells called *touch-bodies*. Some of these cells tell us about pressure, some about heat, some about cold, and so on.

More Senses

How many other senses do we have, apart from sight, hearing, smell, taste and touch?

See how many *other* senses you can think of.

Some examples: **pain, hunger.**

Also, very important: **common sense.**

Water

Do you remember what you learnt about water in Book 3 ?
Water exerts pressure in all directions.
You can see this by taking a tin and
punching five holes in the side with a
nail. What happens when you fill the
can with water? Draw a picture of
the tin with the water coming out.
Now take a tin and bore holes
in a line up the side, like this :
What happens when you pour water in ?
Draw a picture of this tin with the water
coming out of the holes.
The first tin **A** shows that water exerts pressure in all directions.
What rule can we make up by watching tin **B** ? Try to make
a rule of your own about tin **B**.
Sometimes water pressure is used in machines. Sometimes
machines work by using **power** from falling water. Dams store
water, and when it runs out it turns wheels which
make electricity.
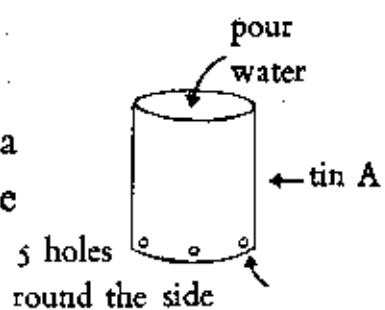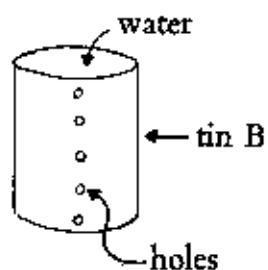
A water wheel

Push a piece of wire through
a cork. Cut slits in the cork and
put in pieces of tin. Water falling
on one side of the pieces of tin
will turn the wheel. How will
you hold the wire ? Your fingers
will cause friction.
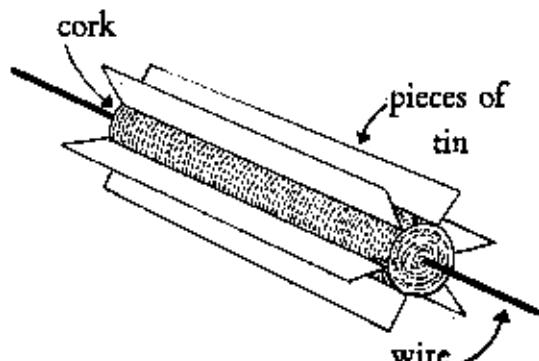
Pistons

A piston is a round block which moves up and down in a pipe. The pipe is called the **cylinder.** To push the piston, and to pull it back again, we attach a rod to it. This is called a **connecting rod.**

The piston   may
The cylinder   be
              big
The connecting   or
rod   small
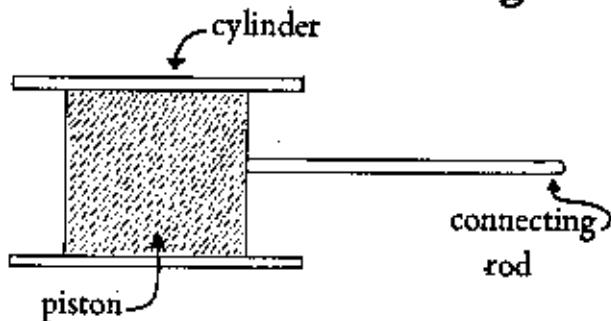
If we move the piston the connecting rod will move. If we move the connecting rod the piston will move.

An imaginary steam engine

Some questions:

1. Would it work?

2. How would the steam get out of the cylinder?

3. How could you put the water in the tin?

4. Why do you need a heavy wheel?

5. Where should the ⊗ hole be?

6. Why is the connecting rod *not* joined to the *axle* of the wheel?

32
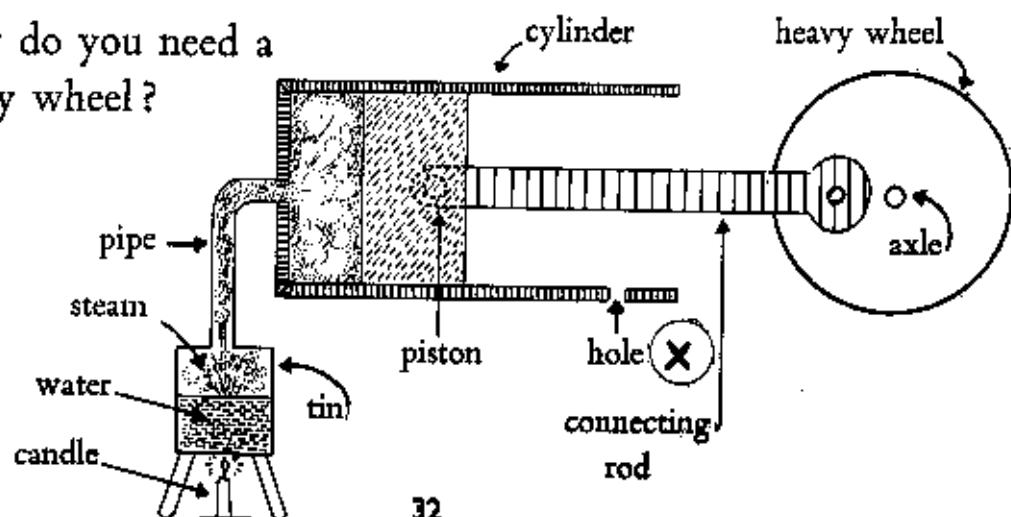
Pistons

Look at page 32 again. Try to think of more *problems*★ which you would have to solve in order to make the steam engine. Write five more questions like questions 1-6 on page 32.

Friction

Do you remember pulling the box of sand (page 24) ?
A big problem for engineers is **friction.**

Friction stops machines from working well.

Friction makes things hot (by rubbing),
Try rubbing a piece of metal (a pen knife,
for example) on a stone. It soon gets hot.
If metal gets very hot it melts and the machine stops.
To reduce friction we can use :

> grease
> oil
> ball-bearing.

To reduce† heat we can:

> pour water on the metal.
> blow air on the metal.

## Two every-day pistons

Try to borrow a pump or spray
gun and take it to pieces. How
is the piston tight in the pipe !
What is the connecting rod made
of? Does the metal of the pipe
(the cylinder) get hot when you
use the pump ? How is it cooled ? Where does the power come
from ? Steam ?

a cycle pump

a spray gun
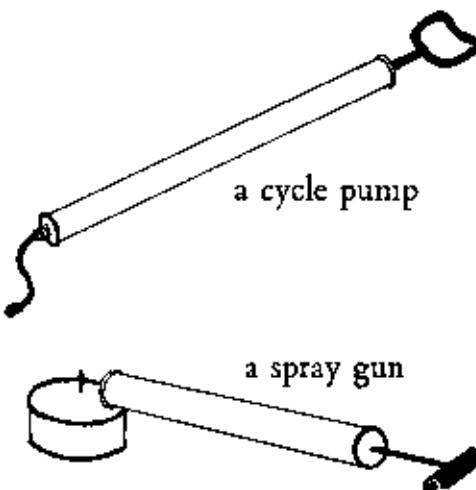
★ A *problem* is a *difficult question.*   † *reduce* means *make less.*

33

Heat

Heat produces* change.

How does heat produce change in these things:

water, wax, paper, wire, people?

Produce five more examples of your own, and show how heat changes them.

When we boil water it changes into steam. If we cool steam it changes back into water.

Heat some water in a tin. Hold a tin plate or *thali* over the steam: put cold water in the plate. See what happens to the steam when it hits the cold plate. Write down your **observations.**†
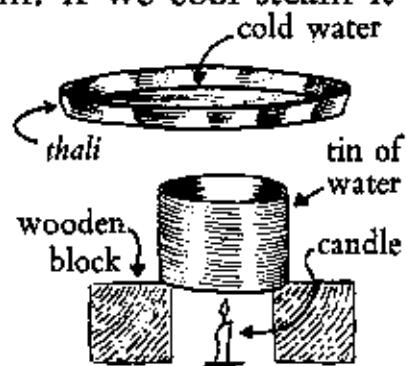
Experiment

You need a brass or stainless-steel *degchi*, a tin, and a paper tray. Set up the experiment as shown. In **A** put 5 teaspoons of water, in **B** 10 teaspoons and in **C** 15 teaspoons.

Question: Which container of water will boil first?

Guess the answer, then do the experiment and see if you were right.
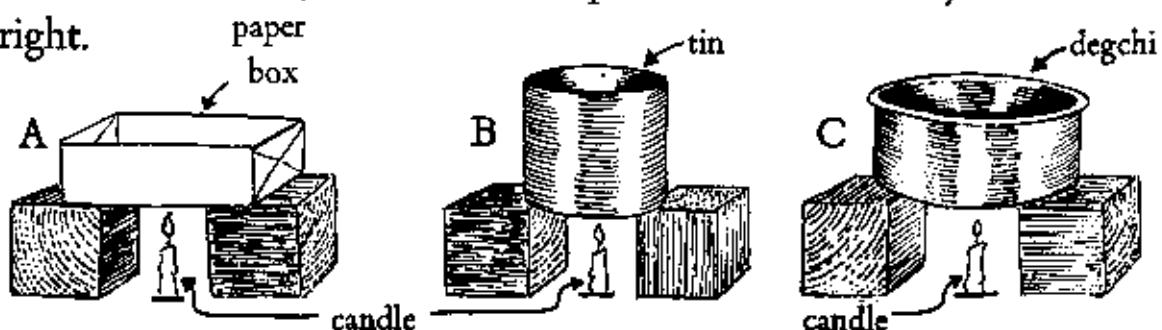
* *Produces* means *makes*.   † *Observations* means *what you see.*

34

Wind

Sometimes the wind blows very hard. We can use this wind as power.

(**A**) It can blow things and make them move from place to place:

sailing ships   balloons   kites.

Can you think of anything else: a car, with sails, which is blown along with the wind; a boat with sails; a huge sail which you hold on to, while it carries you along the road? Write two *problems* about each of the ideas above.

(**B**) The wind can blow things which do not move from place to place. This force can be used to run machines:

windmills   propellors.

Ideas

Scientists discover things by playing with ideas. If you want to learn about science and how scientists work you must get into the habit of playing with ideas.

Thinking — sketching — thinking of problems — how can it be done? These are some of the steps towards discovery.

On the next two pages are some ideas and drawings about **wind power.** Look at them, copy them, try to solve some of the problems, produce new problems of your own, make some of the models, design new ones.

Wind

Sails of card, or wood or tin?

Cork?

pencil

rubber band or string?

cotton reel

angle and shape of sails?

pulley. tin lid?

FRONT

SIDE

best boat shape?

① ② ③ ④

thin bamboo

stiff paper

light wood

will boat overturn?

wright at bottom

keel?

bamboo?

thin card

Cardboard? nail?

36

Wind

cotton reel

pencil or bamboo

will it turn more easily on a pointed or round end?

Cardboard

thin Cardboard

front view

plan

drive to pulley

cotton reel with stiff wires on top

rings small bell on string & scares birds

string

thin card

stiff wire

fixed pieces of wood

sitar strings
wind blows card and wire plays strings

whistle

W I N D

cone of paper

Soil

Soil is formed* from rocks. The rain falls on the rocks. Plants grow and produce cracks in them. The wind blows against them. This is called weathering.

Humus is made of dead vegetable matter, such as plants and leaves. It is very good for growing new healthy plants.

Sand and **clay**. See if you can find some sand and clay near your school: compare them both with garden soil.

Write a few lines about the differences you find in them. Do they all look the same? Do they all feel the same? If you take a pinch of each, does the pinchful stay as a lump or fall into small pieces? What happens if you make them damp? Do they all weigh the same?

An experiment

We want to find whether WATER passes MORE EASILY through garden soil, sand or clay.

   (a) Write down your guess. Write down a reason for your guess. Scientists call a reason for a guess **a hypothesis.**

   (b) Design an experiment to find out.

   (c) Set up the experiment.

   (d) Check your guess. If your guess was right, can you be sure your hypothesis was right too?

* *Formed* means *made*.

Cells

All living things are composed* of **cells.**
There are many different kinds of cell.
Most cells look like this:
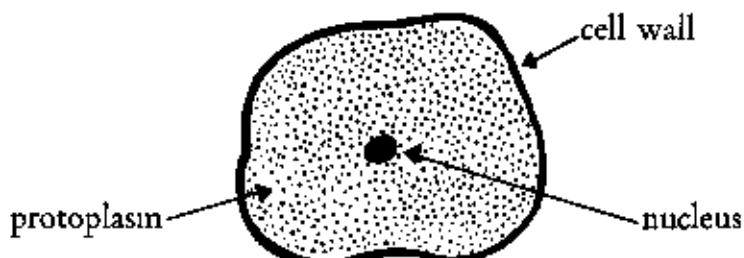
Protoplasm is a jelly-like stuff, rather like the white part of
an egg. The **nucleus** is the central living part of the cell. If the
nucleus dies the cell dies. Cells are so very small that you
cannot see them.

Living cells and dead cells

Sometimes cells are killed by boiling water. Set up the
experiment shown:

(a) With a fresh potato
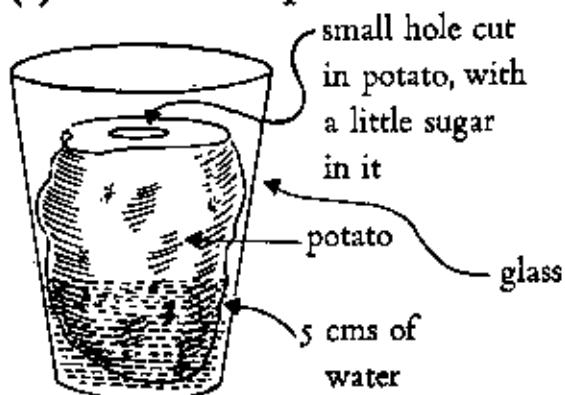
(b) With a boiled potato

Carry out experiments (a)
and (b). Leave each potato
in the water for 2 or 3
hours. Write down what
happens. Try to explain
what happens.

* *Composed of* means *made of.*

The Solar System

Here is a *rough* diagram of the four planets nearest the sun.
Round the sun there are a number of **planets.** The planets all
move round the sun in paths which are nearly circular. These
paths are called **orbits.**

The Earth

The Sun

Mars

Venus

Mercury
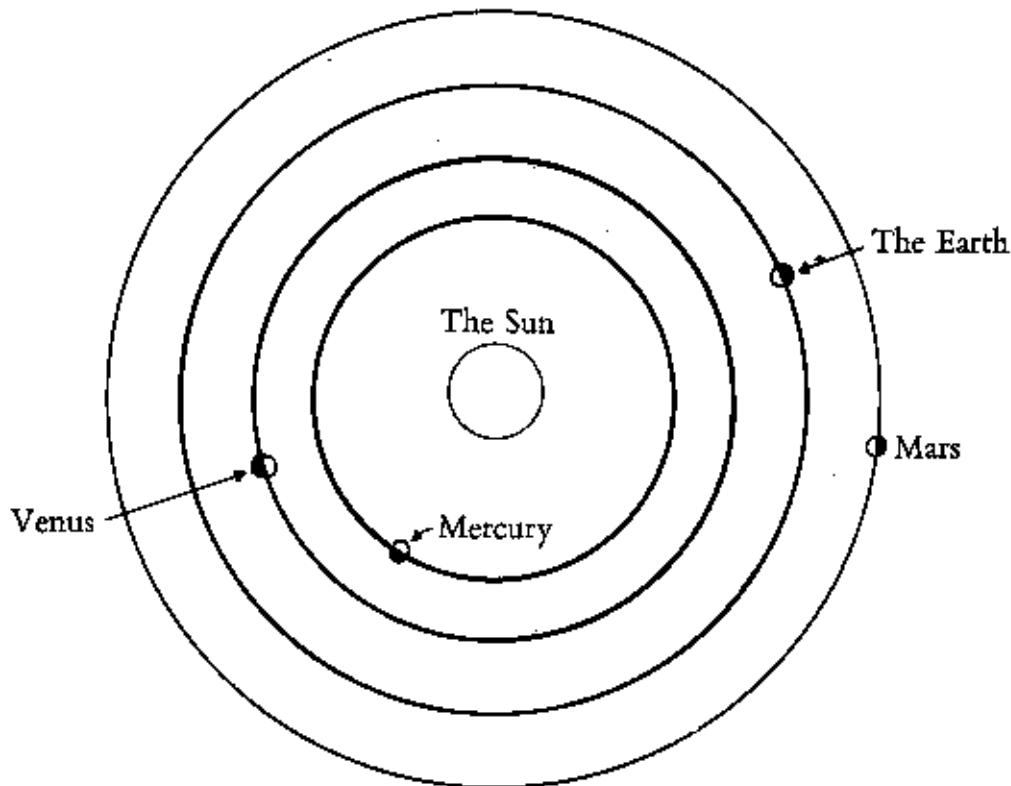
The earth is a planet, too. The planets do not give out light.
The sun shines on them and we see them in the light of
the sun. If we had a car which
travelled at 500 miles an hour,
we could reach the planets in
the times shown here.

Venus	6 years
Mars	8 years
The nearest star	4 million years.

The Solar System

The earth turns round on an imaginary axle, which is called the earth's **axis.**

Things to do

Keep charts for a month of:

(a) Sunrise and sunset times.
(Do they change every day?)

(b) The shape of the moon.
(Can you see it every night?)

Ask your teacher the names of all the planets.

(Only four are shown on page 40.)

Ask your teacher or a friend about the stars. Some of the stars form patterns or groups in the sky. These groups of stars are called **constellations.** See if you can find these groups:
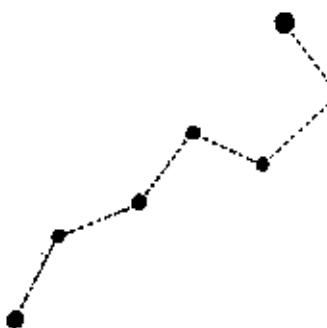
See if you can find:

Gemini **The Pole Star**

Leo **Sirius**

Papier Mache

Papier mache (pronounced papeeay – mashay) comes from the French, and means chewed paper. It is useful for making all sorts of models. This is how you make it.

You need paper and flour paste. You make the flour paste by mixing white flour or *maida* with water: put in enough flour to make it like thin curds. Cook it slowly until it boils, stirring well all the time.

Now tear up the newspaper into pieces as big as postage stamps, and put them in water for 24 hours. Then squeeze out the water and mash them on a curry-stone.

Mix the mashed paper with paste as shown below.

## Making papier mache

(1) Tear six newspapers into small pieces.

(2) Soak them in a bucket for twenty-four hours.

(3) Mash them on a curry-stone.

(4) Squeeze out all the moisture and mix with flour paste.

Three cups of paper

One cup of paste

Things to Make with Papier Mache

Many things useful to you in studying science can be made with papier mache. When it is dry it is very hard and does not break easily. Here are some ideas; you can easily think of more ideas of your own:

birds and animals

painted

wire legs

insects

wire legs

model butterflies (paper wings)

geometrical solids

matchstick before it dries

weights for weighing

corks for experiments

corks with holes in them

models of bones

pulleys for models

wheels of any size

connecting rod

pistons (wind with string to make tight)

gear wheels of any size

holders for mirrors

candle holders

model boats (use enamel paint)

Reading a Drawing

This is a **section** drawing of something.
What is it? Does B move
up and down? Does A
move up and down or
round and round? What
does the line of small
arrows mean ($\rightarrow$ $\rightarrow$ $\rightarrow$)?
What do you think E is
for? It is made of leather.
How is A fixed to B?
How is E fixed to B?
Have you one of these
things in your house? The
part E is called a **washer**.
Why is it made of leather?
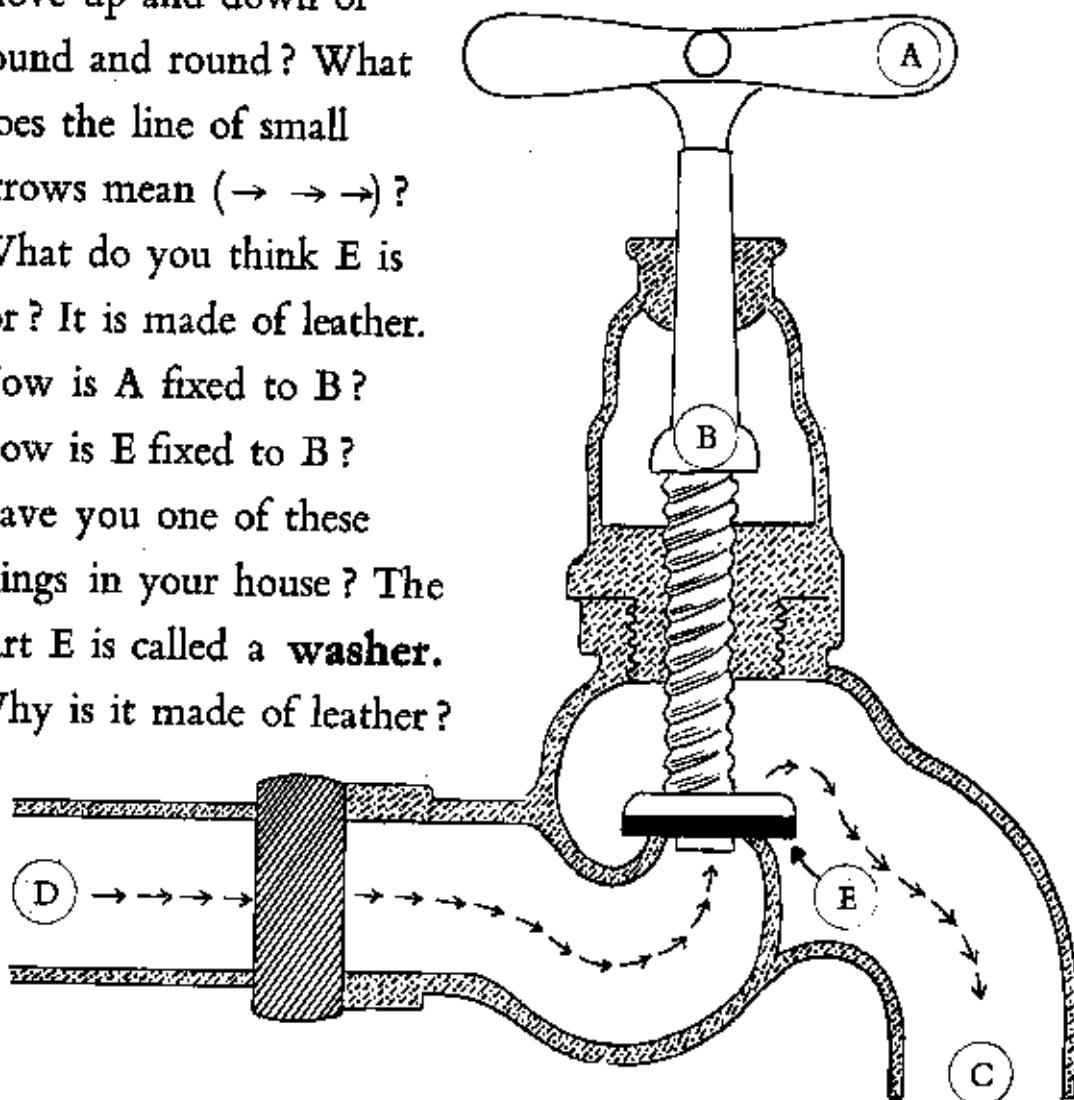
Copy the diagram as carefully as you can into your books.
Try to make a section drawing of one or all of these things:

a pencil sharpener   a fountain pen   a top

Travelling

Travelling means to move from place to place.

Scientists are very interested in how things travel.

Write down **10 ways** in which human beings travel.

Here are some ways in which things travel. Write them in your books and then try to write what things travel in them:

Pipes

Wires
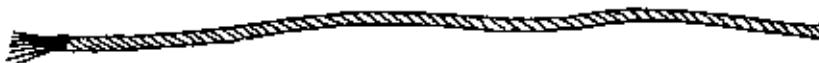
The air ———⟶

How do the following things travel:

blood, water, telegrams, telephone messages, flower seeds, steam, the sounds of a flute, the heat from a fire, fish, ants, letters, ideas?

Moving Stones

Would this machine work? What problems would there be in making it? What could you make A of? What could you make B of? Would it be faster than carrying stones in the ordinary way? Does the belt A travel or do the stones travel?

Drawing

Drawing a large circle (too big for your compasses)
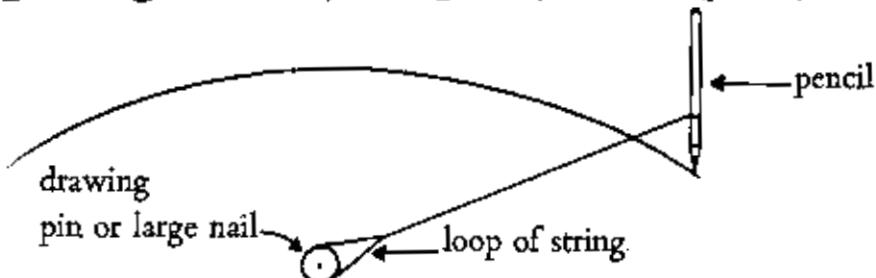
With this method you can draw large circles in the playground.

Drawing an oval
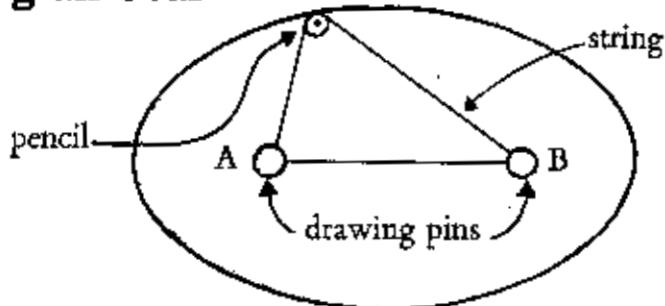
There are two important dimensions in drawing an oval:

    1. the distance between the 2 pins

    2. the length of the string triangle.

Experiment with

    (a) a different distance between A and B

    (b) a longer or shorter triangle of string.

Can you draw ovals with these dimensions?
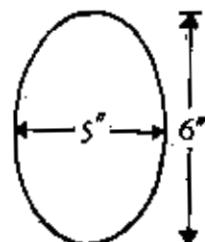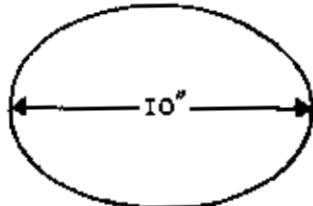
Bird Models

Do you remember the bird models you made in Books 2 and 3 ?
They were:
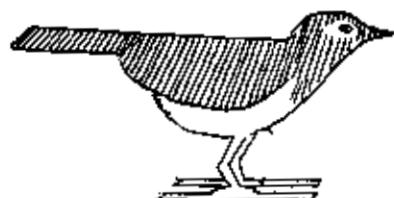
The Hoopoe	The Pied Wagtail
The Tailor Bird	The Kingfisher
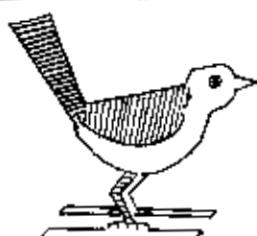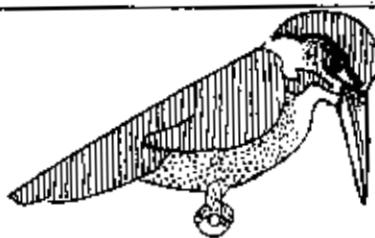
On the next two pages are two more models. Trace the pictures.
Do not cut the book. Then make new drawings on clean white
paper. Do not trace the numbers, lettering or shading: they are
to tell you what colours to use and where to stick the models
together.

Follow this order of work:

Trace.

Put on white paper.

Paint with the correct colours.

Cut out carefully.

Stick where required. (Use cooked rice or paste.*)

* Instructions for making paste are given on page 42.

Bird Models

Body. Fold at V Y. Stick heads together above this line

no paste on body below this line

Tail
Cut
one.
Fold
along
A---T.

A B
is stuck
on to
Y Q
parallel
to
Y X.

cut away

fold
in and
paste.

Beak — red
Circle round neck
— black and rose
Body — green

cut
away

Wings
Cut
two
and stick
at (W).(W)

The Parakeet

48

Bird Models

Body: Fold along B-B. Stick heads together above this line →

↑ no paste below this line.

cut away

cut away

Wings: Cut one, & fold along A-A Stick on to body at W-W. Note that A-A does not lie along B-B.

Beak – red

Body – green with reddish brown on back and head.

Black on necklace and round eyes.

Green Bee-eater

49

The First Railway Engine

Many years ago the first railway engine was made
by a man called George Stephenson. It drew a load of
13 tons and went at a speed of 29 miles an hour.
The newspapers said, 'You might as well expect
people to let themselves be fired off in rockets as
trust themselves to railways.' So Stephenson called his
engine 'The Rocket'.
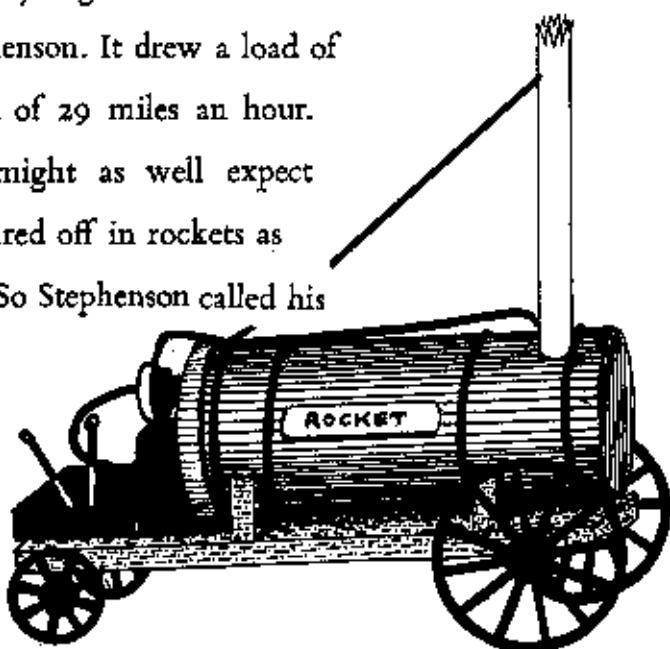
Making 'The Rocket'

Read carefully the plans and instructions on pages 52 and 53. Some of the plans
are not full size, but dimensions (in centimetres) have been given. Mark out
these plans on cardboard, then cut them, fold them, and stick them together.
Cover the joins with paper and paste to make them stronger. The cylinder circles
and the cylinder carrier have all been drawn full-size. Trace them and make up
as shown. When the cylinder is finished it must be stuck on to the carrier in the
place shown. The hole in the cylinder must point towards the peg on the front
wheel. This peg can be made of a matchstick cut in the half; the hole in the
piston rod goes over it.

The rear of the engine can be made of two matchboxes, and a small round cap
stuck on for the steam regulator. Controls are made of matchsticks.
The pipes can be made of painted string, glued in position.

Rocket

BASE Cut one

6 | ←3→ | ←4→ | ←3→ | 3 | 4 | 19 | 6 | 3 | 3 | 4

BASE

hole for axle

REAR AXLE CARRIER Cut one

3 | 6 | ←3→ | ←3→ | ←3→ | ←3→ | 3

cylinder goes here

Bend over

Bend under

Bend under

full size plan (trace)

Bend under

CYLINDER CARRIER Cut one

Rocket

cylinder end cut one

6

card 6 can

$2\frac{1}{2}$

1

stick

section of cylinder

cylinder bores Cut two of stiff can

cut two to fit boiler

cylinder

6

boiler

paper 14

hole for chimney

16

Boiler Cut one of stiff paper

card end of boiler

5

bamboo or pencil

axles — cut 2

Card board washers

stick on each wheel

8

Cut 2

chimney Roll of paper. Cut one. $1\frac{1}{2}$

front wheels diam. 8

Rear wheels diam. $4\frac{1}{2}$ Cut 2.

linkage - piece of paper clip

7

8

match stuck in front wheel to take ⊗

⊗

piece of cardboard

piston linkage - drinking straws with bamboo inside

Solids, Liquids and Gases

Everything in the Universe is made of **matter.**

We say that matter is something which has weight.

Of course, there are plenty of things in the world which are not made of matter — a poem, for example, or a feeling of hunger.

Matter has 3 forms:

SOLID, LIQUID or GAS

A good example is water:

1 ICE (Solid)	2 Ordinary WATER (liquid)	3 STEAM (gas)

Write four headings in your books:

solid, liquid, gas, non-matter

List the following under the headings you think are correct:

wood, steam, a brick, smoke, ink, pencils, lime-juice, a song, your leg, milk, fog, a dream, a shirt, honey, grass, air, brass. clouds, fear, a jalebi.

Heat

Can you see how the changes above, from 1 to 2 and from 2 to 3, were made? Heat was applied.* If we heat ice it will turn to water. If we heat water it will turn to steam.

Most solids can be turned to liquids, and then to gases by applying heat.

* *Applied* means *put on.*

Gas

As you know from page 54, gas is one form of matter. Gas has some very useful qualities* :

It is very elastic.

It expands when it is heated.

It can be compressed.

It also has some other qualities which you will learn about in Book 5.

How are these qualities of gases useful to us?

You have seen how a steam engine works. The steam (gas) has expanded because of heat, and presses against the piston. This turns the wheels. Compressed air (gas) is very useful: we put it into cycle tyres.

An experiment

Take the lid of an ink-bottle, and put a piece of wire round it to act as a handle. Hold the handle with a handkerchief. Put into the tin lid one teaspoon of sugar. Heat it. Watch very carefully, and write down everything that happens. Get a friend to hold the wire, while you both observe and you write.

Note carefully: change in colour, change in form, smell, anything else which happens.

Discuss what you saw with your teacher.

* A quality is something which makes a thing different from another thing.

Lifting Weights

You have already learnt something about levers and pulleys in Books 2 and 3. Look at the machine on the right: perhaps you have seen someone lifting up water from a well in this way. You can easily make a model one of your own: you will learn a lot from it. You need a piece of stick with a fork at the top, a cross-bar, a small stone, a piece of string and a tin. What are the best sizes for AB and CF? Should they be the same? Is AC equal to CD, or should it be shorter? Does the weight at D equal the weight of the bucket plus water, bucket minus water, or is it lighter?

Try out different weights and lengths and design the most efficient* machine.

Pulleys and drives

Look at page 57 (more playing with ideas). Copy some of the drawings. Make models. Try using the pulleys. Try using the belts. You will find a chain drive on a bicycle.

What power is used in making a bicycle move? Does the rear wheel go round faster than the wheel which carries the pedals, or does it go at the same speed?

* *Efficient* means *doing its work well.*

Pulleys and Belts

big pulley makes small one go faster or slower?

faster or slower?

crossed belt changes direction

bottle tops as gears?

pins

cotton reel

should pins be in middle or at side? two lines?

Model Persian Wheel

ladder of string + string, wire or pins

Model Lift

weight

small man

cotton reel

cups of toothpaste tops

or

ground nut halves

57
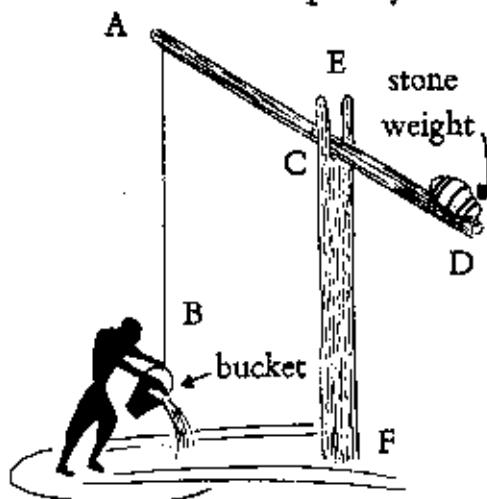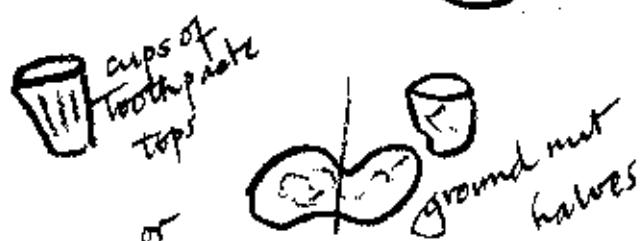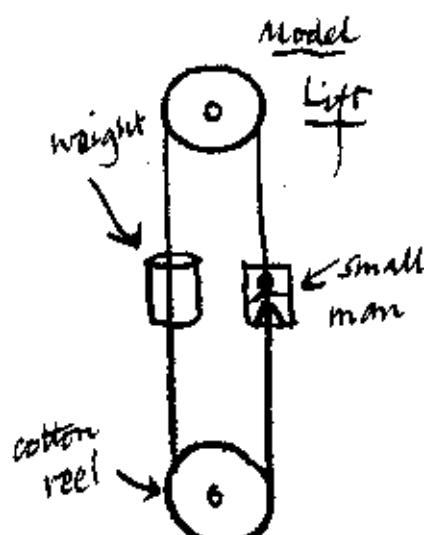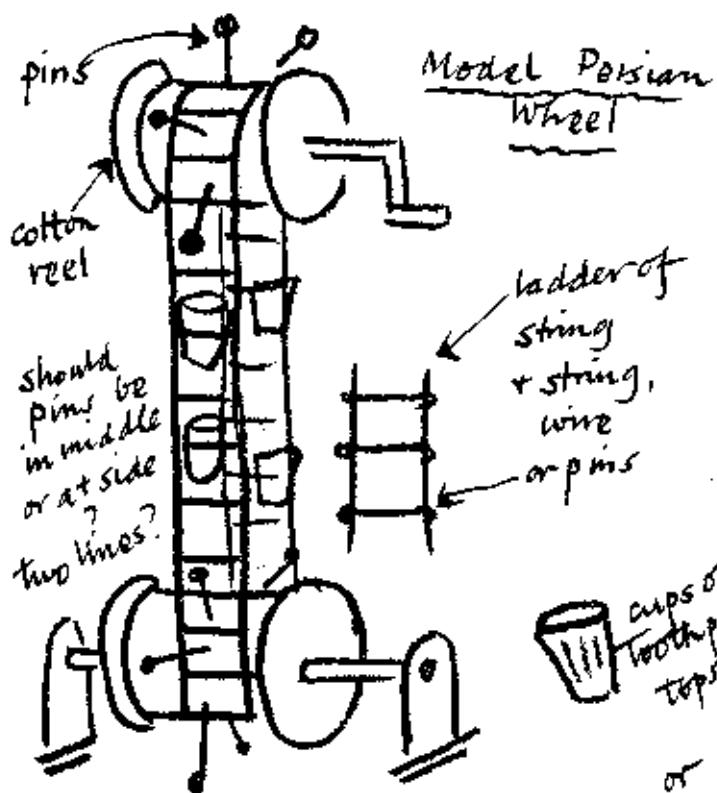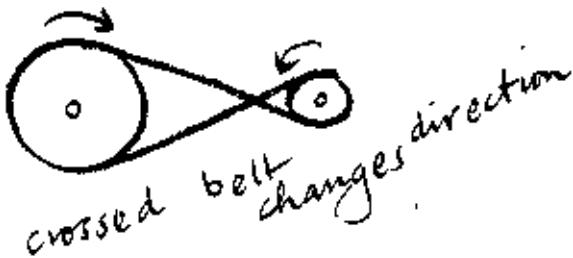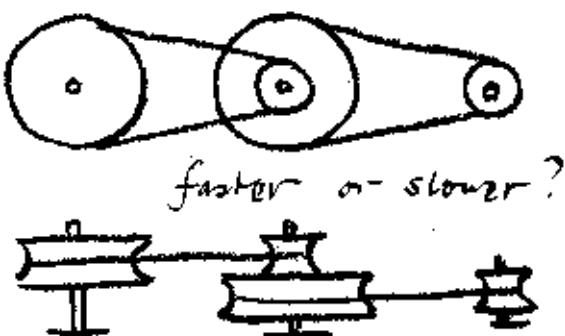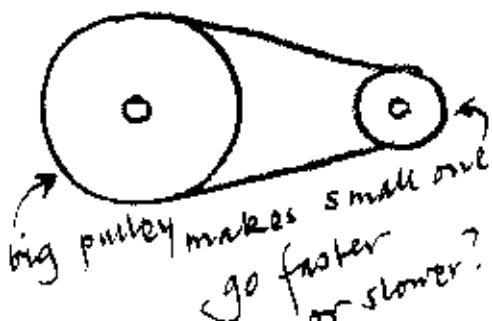
Heat

Do you remember the experiment you did in Book 3 ? Try it again. Stick some pins on to the wire with melted wax. In Book 3 you had a pointer at the end of the wire, which showed that metal expands when it is heated. The experiment above will show you how heat flows. You can measure the speed of the flow by seeing how long each pin takes to fall off. What happens to air when it gets hot ?

Try the experiments shown, write down what happens, and then say two things about air when it gets hot.

Put the bottle in hot water and see what happens.
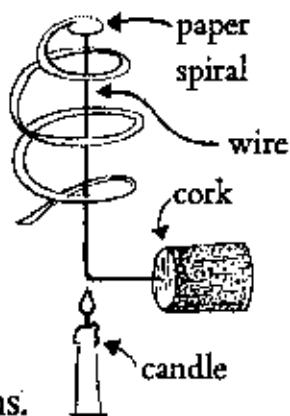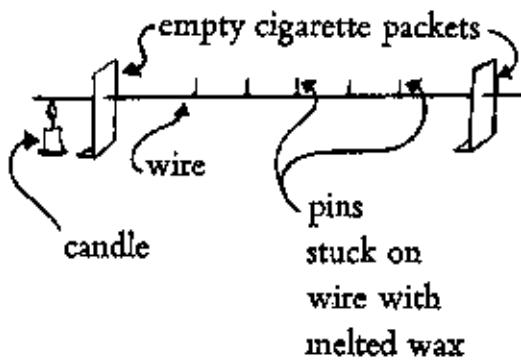
Another experiment with heat

Cut a tin into two equal halves. paint the inside of one tin with black paint. Put a candle in the exact centre, between the two halves. Stick a matchstick on each side with wax. Which falls off first ?

A trick

Arrange a matchbox and 2 matches as shown. Light the horizontal match at X. Which match will catch fire first, A or B ?

58
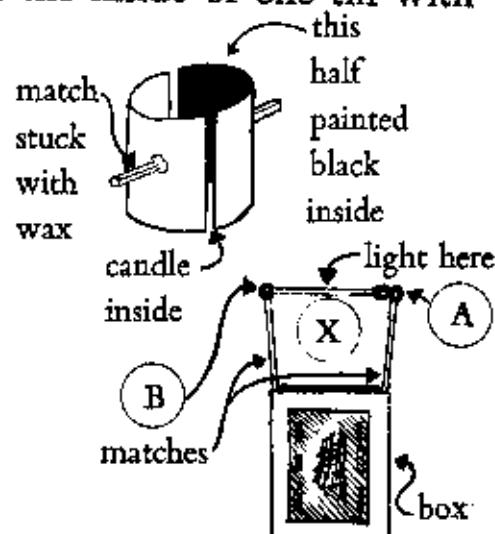
Heat

Carry out this experiment. You need 3 empty boxes (chalk boxes will do) and 4 containers of the same size. These can be empty ink bottles, tins with lids or metal tumblers. Make some water very hot (not boiling) and pour it into the containers: make sure that each container has the same amount of water in it. Put the lid on each container (a piece of card if you are using glasses), and put one container in each box, right in the middle, surrounded by paper, hay or sand as shown above. Put some packing on top of the container too. Leave container No. 4 outside.

Put your finger in each container (carefully!) at intervals of an hour: write down what you observe about each.
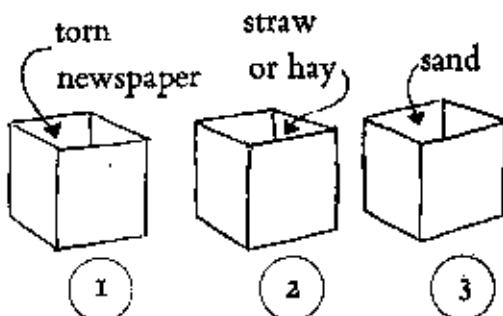
The Thermos Flask

Probably you have seen a Thermos or vacuum flask. A vacuum is a space with no air in it. The space between the two glass walls (the outer and inner walls) is a vacuum. If you have a vacuum flask, experiment with it to see how long hot water keeps hot. Does it work better than the boxes in the experiment at the top of the page?
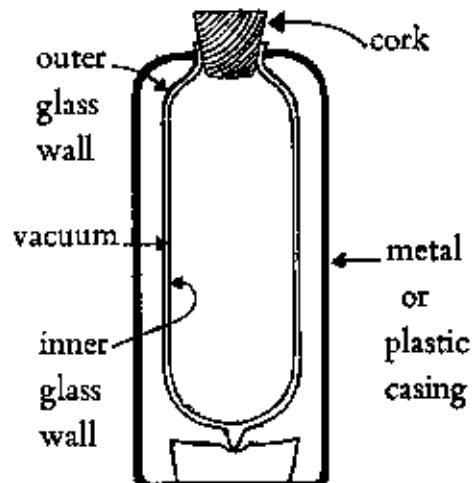
Electricity

Do you remember what you learnt about circuits? Dry cells always have two terminals,* a positive and a negative terminal.
For positive we write + (plus).
For negative we write − (minus).

brass terminal

Dry cell

+

When we join a wire and a bulb to a cell, the electricity flows **from the negative to the positive.**

+ −

The current flows in the direction of the arrows.
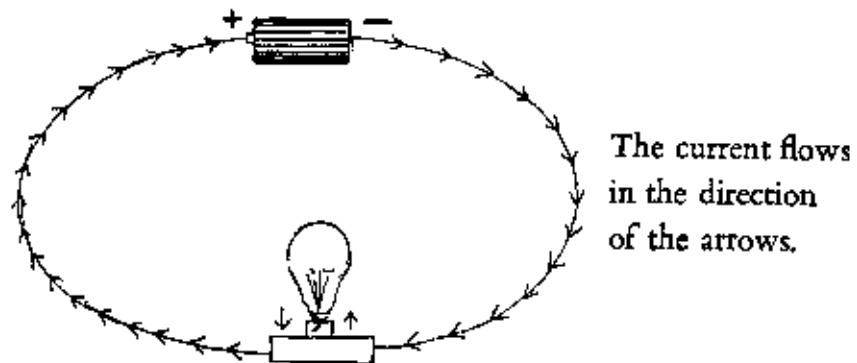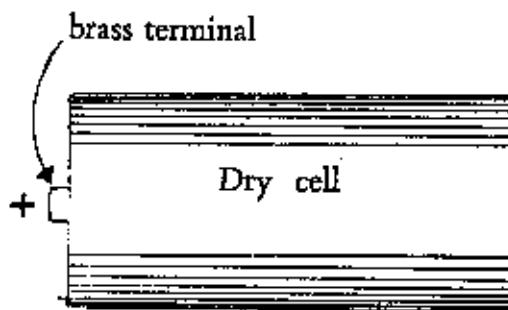
Testing

Some cells have two screws on top. If we cannot tell which is + and which is −, we can do a polarity test. Attach one wire to one terminal and one wire to another. Put both wires into half a potato. Leave them in for a minute or two. The wire from the + terminal will have a greenish blue rim round it: there will be no colour round the other hole.
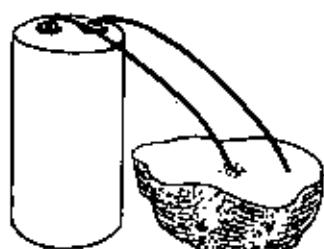
* *Terminal* means *something at the end.*

60

Electricity

You can carry out another polarity test with a glass of vinegar. Attach a copper wire to each terminal, and dip the terminals into a glass which contains some vinegar. Watch

the ends of the wires carefully. What happens to each end ? Observe carefully and then write down what happens. Find out which wire is from the **+** terminal and which from the **−** terminal. How ? Look at page 60.
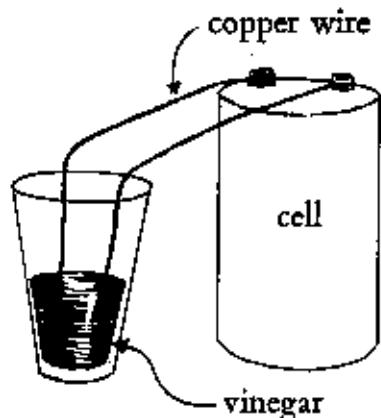
A cell

Draw a section of an ordinary cell (from a torch) in this space. ⟶
How will you do that ?˙
Find a cell which someone has thrown away. Attack it with a knife, but do it carefully, so that the cell is not destroyed. Look at what you find inside.
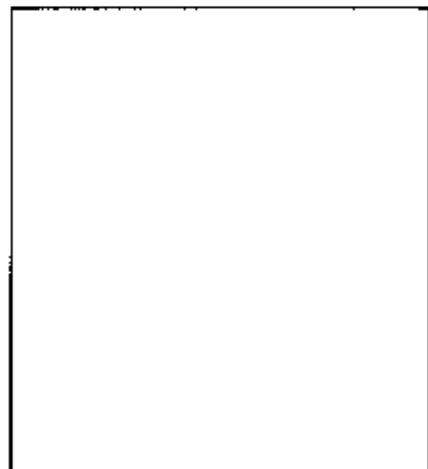
    Try to describe it.
    Try to draw the section above.
    Are any bits of the old battery useful ?

Biology

The Greek word for life is *bios*, and biology means the study of living things. The materials for biology are all around us:

> ourselves, animals, insects, birds,
>
> plants and hundreds of other living things.

You have already learnt something of Biology in previous Books, and in pages of this book; but no one can teach you Biology— you will have to learn for yourself.

> Observe — observe — observe!

Chemists say they can see 50 chemical changes going on in a candle flame: we can only see the flame.

Observing

Catch a frog and put him in a large jar. Put a little water in the jar, and cover it with cotton cloth.

> Observe it. Write. Draw.

(The Latin name for a frog is *Rana*.) Write (and draw) about
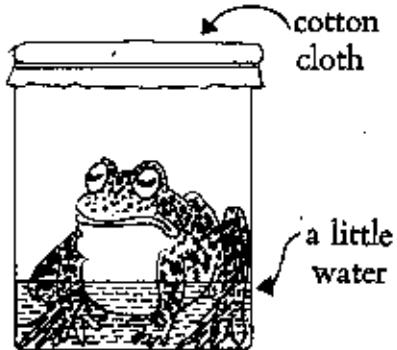
> its eyes — ears — how does it breathe ? — legs — not all the same length — why ? — toes — how many ? — skin — colour — rough or smooth ?

Catch a fly (by putting a glass over one, and then sliding a card under the glass): take off the cotton cloth and put the card on top of the jar. Slide out the cardboard.

> Watch.

What is the tongue of the frog like ? Does it shut its eyes when it eats ?

Don't stop at the frog. Do the same with insects and plants.

Screws, Nuts and Bolts

If you look at the three pictures above, it is easy to see which man has the most difficult climb. The steeper the hill, the harder the climb.

Take two triangles of paper, with the dimensions shown here, and place a pencil at A-B. Then wrap the △ of paper round the pencil. Draw each one: What differences are there?
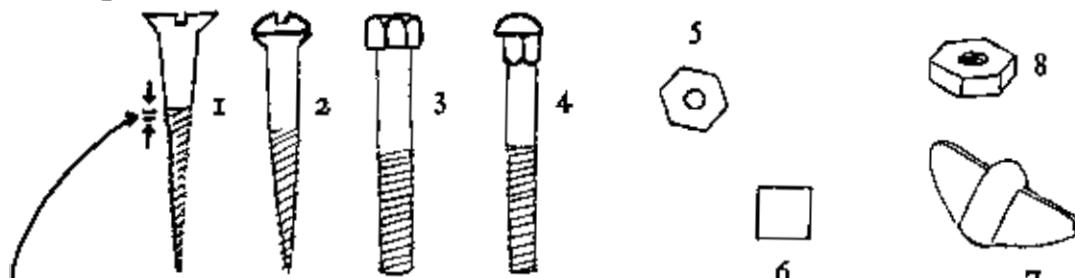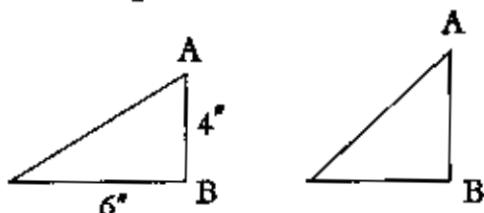
This distance is called the pitch of the screw. Above you can see pictures 1-8. Each one is different. Draw each, and try to say what each is. Some are nuts, some bolts, some screws.

By the side of each drawing write a note or two saying what each is used for. Then write a note giving details of something you have seen recently which uses such things.

All sorts of screws and bolts are used in all sorts of things. Find new kinds, not illustrated above, in and around school. How are they different? What are they made of?

(Some help: cycles, desks, doors, buses and cars, machines of all kinds, pencil sharpeners, compasses; and hundreds more things)

Chances

Do you remember the dice you made in Book 1 ? If you have lost them, make some more. You need two, of different colours. Below is a chart which shows all the possible throws with two dice. It is not complete. Your first job is to fill in the blank squares.

Each square above has a reference number.
Put your finger on square 6A. Now on 4B. Now on 3F.
Now make a list of all the reference numbers, like this:

     1A   1B   1C, etc.

Now throw your dice a hundred times, and put a dot by each reference number when that throw comes up. For example, if ⊡ ⊡ comes up, you put a dot by reference number 3A. Get your friends to do the same.

Then make another list of reference numbers, and add in your friends' results, like this:

	Ravi	Suneet	Sandra	
1A	2	—	6	
1B	4	5	2	
1C	—	1	1	and so on.

Add up the totals. What results do you get?

Ecology

Ecology is the science that deals with the relationship between living things and their environment.

Environment means what is all round us.

Ravi lives in Bombay.

Ashok lives in a tiny village in Andhra Pradesh.

Minakshi lives in Trivandrum by the sea.

Asha lives on a farm in Kashmir near the lake.

Write three sentences about the environment of each child.

The environment changes people, and changes ideas.

Jack, who lives in New York, thinks that milk comes from a milk factory.

Asha lives on a farm, and sees that milk comes out of the cow.

The environment has an effect on our lives.

Draw yourself here.

1. A boy in a village who looks after goats
2. An Eskimo boy who fishes through the ice
3. You
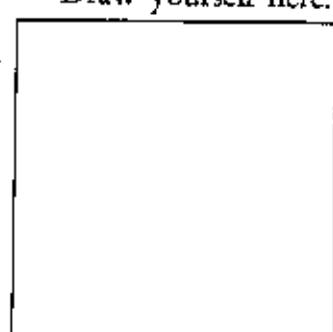
How does the environment affect 1, 2 and 3 above?

What effect does it have on:

houses, clothes, food, schooling, games, work, pet animals, ideas?

Effective Communication

Effective means working well.

Communication means passing on information or news to someone. Scientists have to be careful when they communicate with each other. The person who receives the message must receive the message the sender wanted to send.

For example, if I think this is an elephant,

and I talk to you about elephants — how sweetly they purr, how I give my elephant a saucer of milk every day, etc. — we shall not have any effective communication.

We use many ways of communicating: you have read about some of them in Books 1–3; for example, language, symbols, smoke signals, Morse code, diagrams, etc.

Scientific communication must be

     CLEAR and PRECISE*

For example:

(1)

Yesterday I saw such a pretty plant — it had biggish leaves, and a sort of longish — no, roundish, fruit — the colour of my aunt's new sari — it was quite tall — the plant, I mean, not my aunt — and lots of leaves — oh, you know what it was!

(2)

The Brinjal
(*Solanum melongena* L.)
Hindi name: *baigan*
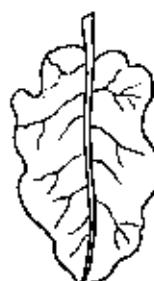
Simple leaf, net-veined. Fruit purple, globe-shaped, 10 cm long. Plant average 60–80 cm high.

* *Precise* means *exact, correct.*

Effective Communication

Notice the difference between the two descriptions of the brinjal on page 66.

Clear writing is important : diagrams are equally important. Quite often instructions are made much clearer by a map or a diagram. For example :

Start at the statue on Main Street and walk East. Take the second turning on the right, the first turning on the left, then the first turning on the right. Our house is the third house down on the left of the street.

A map makes things clear and easy :

Your route _____........................_
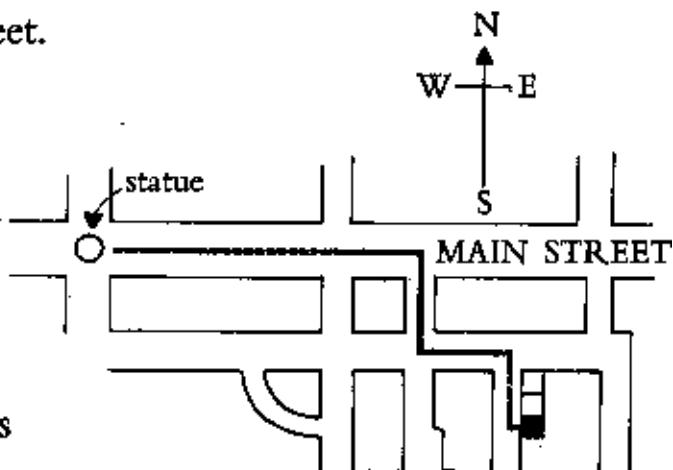
Practise writing definitions
　　　　making diagrams
　　　　labelling parts (There are plenty of examples in this
　　　　　　　　　　　　　　　　　　　　　　book.)

Write definitions, and then make labelled pictures, of the following :

　　　　a pen　　　a clock　　　a dog　　　a flower

Give the definitions without the labelled diagrams to a friend. Ask him or her to make labelled diagrams to suit your definitions.

Automatic Control

Automatic means works by itself.

Control means to direct or to guide.

Scientists and many other people are interested in automatic controls. For example:
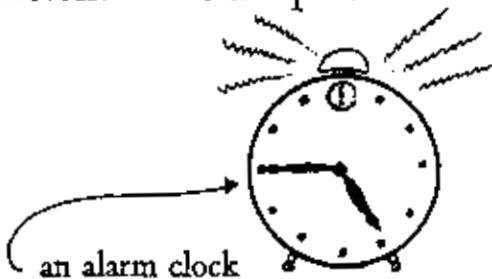
You set the hand at six, and at six the bell rings automatically: your sleep is controlled by the bell.

an alarm clock

Very often scientists, when they are carrying out experiments, want to control things automatically. For example, there is a thing called **a thermostat.** When the temperature of water in a boiler becomes as hot as the scientist wants it, the thermostat clicks a switch and this turns off the heat.

A thermostat is an automatic control. It doesn't need a man to watch the thermometer: it works automatically.

Playing with ideas

On page 69 you will find a page of drawings.

> Look at them.
>
> Copy them.
>
> Improve them.

Think about some of the problems in making them.

> Try to make them.
>
> If they don't work, design them again.

Automatic Controls

inlet pipe

metal strips   screw

wire   bulb

wood

empty tin

batteries

WATER

water tank.

as water level rises, tin floats up. Top of tin pushes two metal strips together and lights bulb.

Q's — How could you be sure the tin would come up straight? A wire? A piece of wood?

box of sand. Sand falls out of hole in corner into pot.

stone = to weight of pot 3/4 full

bulb

wire

wood

metal strips

post

water dripping

batteries

Sand falls into pot: when it is more than weight of stone it hits metal strips together

bamboo

stop

Where should ⊗ be?

Drawing

Very often when we are making a diagram, we want to divide a line into a number of parts, say 4.
If the line is
like this ⟶ _____ 8 cm
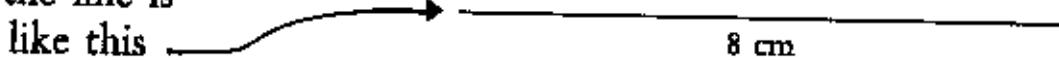
it's easy — we divide 8 by 4, and make divisions of 2 cm.
What do we do with
a line like this? ⟶ _____

We use parallel* lines.   7 7/10 cm   (7 cm 7 mm)

Which of these pairs of lines are parallel?

① ② ③ ④ ⑤ ⑥
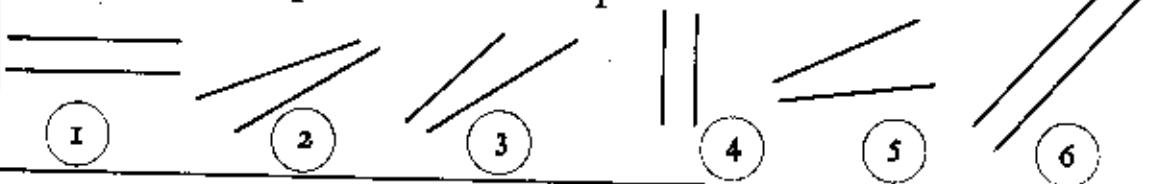
Do it this way:
1. Draw AB = 7 cm 7 mm.
2. Draw BC in any direction, the angle is not important.
3. Mark off BC in 4 equal divisions. Before you draw BC, make sure it can easily be divided into 4; i.e. make it 8 cm or 4 inches.
4. Join ☐ to 1, ☐ to 2, ☐ to 3
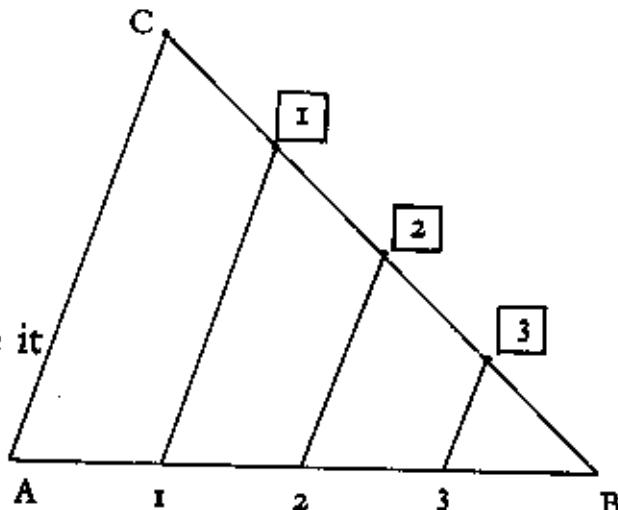
Make sure the lines are parallel. AB will be divided into four pieces.

Practise with the following:

       Divide a line 9 cm into 5 parts.
       Divide a line $16\frac{1}{2}$ cm into 7 parts.
       Divide a line . . . . (Put in your own figures.)

* *Parallel*: going in the same direction; straight lines which are parallel will *never* meet.

Chemistry

Do you remember what chemists are interested in?

Substances — their properties — the effect they have on each other. In Book 3 you read about the example of the chapati. The substances (flour, etc.) joined together and had an effect on each other.

Sometimes the chemist wants to separate substances from each other. Separating things is called **analysis.** Imagine a mix-up of these things:

SALT
SAND
IRON FILINGS
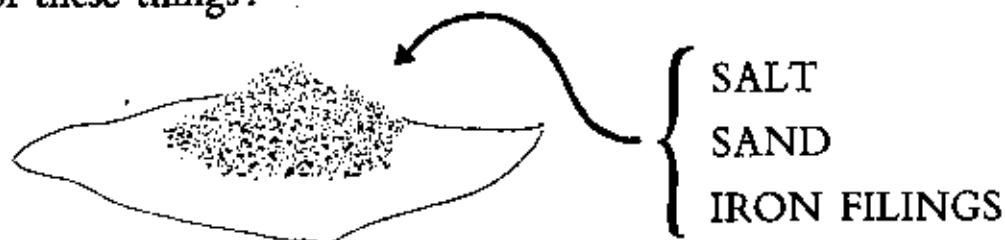
How do we separate them?

A. Use a magnet over the pile.
   This will take out all the IRON FILINGS.

B. Put the sand and salt in water. The salt will dissolve. Pour the sand and water through blotting paper. This will take out the SAND.

C. Boil the water gently. The water will change to steam. This will leave the SALT.

How would you analyse or separate the following?

1. Some grains of rice which have stuck into a ball of wax.
2. Some iron filings mixed with bird's feathers.
3. Some small stones mixed with wheat grains.
4. Some paddy husk mixed with paddy grains.
5. Some powdered chalk and powdered salt.

Science and the Farmer

How can the scientist help the farmer? Think first of what the farmer wants to know.

He wants to know: if the soil is good.
if the seeds are good.
what fertilisers to use.
what the weather will be like.
what machinery he can use.

Discuss with your teacher the ways in which science can help the farmer with the questions above. Think of more questions.

Seeds

The farmer wants good seeds. All the seeds should germinate.*
The scientist can test germination and produce good seeds for the farmer.

Experiment

Set up your own experiment, with a few friends, for testing germination. Try to fill in the chart below. You will have to put the seeds on wet cloth, and count the sprouted seeds every day.

No. of seeds germinated			
100			
90			
80		P	W
70		A	H
60		D	E
50		D	A
40		Y	T
30			
20			
10			
0			

Add the names of any seeds which you use for this experiment.

5th day ▨   6th day ▦   7th day ▢   8th day ▥   and so on
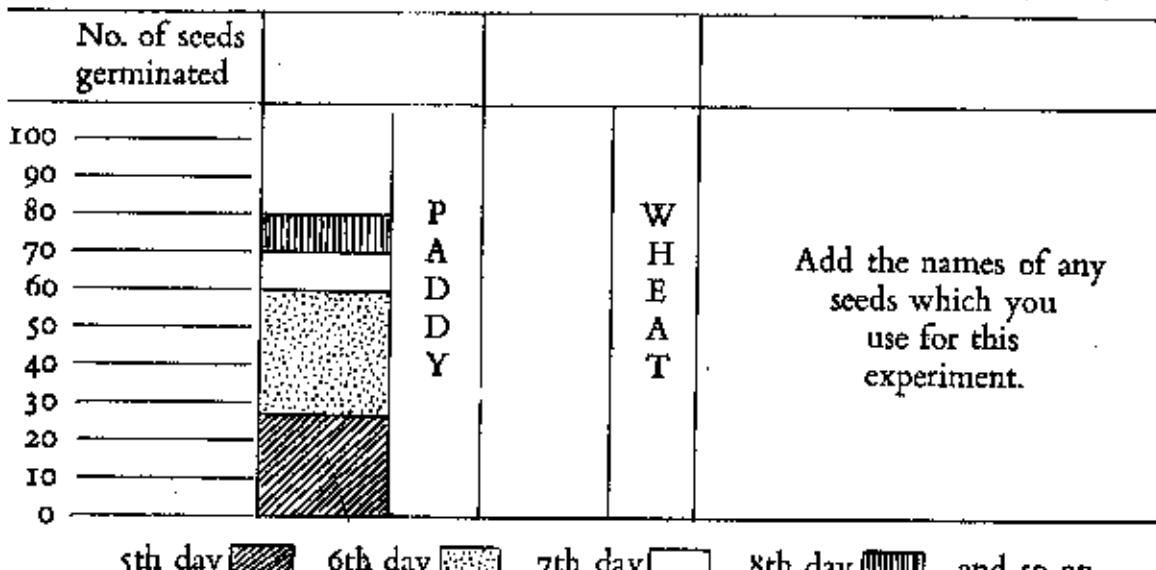
* *Germinate* means *start to grow*.

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Scientist's Languages

As soon as we begin to study science we have to learn a new language.

Each branch of science has its own language, and therefore there are a great number of 'science languages'.

However, most scientists use one or more of the following 'languages':

Symbols   All scientists use symbols: they are quick ways of writing things down. For example, write down in words what we mean by:

$(3+2) \times 5/2\ (2+1)$

'Add together three and two, then'....

It will take three lines.

Latin words   Latin and Greek are much used by scientists.
  All doctors know what CEREBELLUM means.
Greek words   All botanists know what PARENCHYMA means.
  All biologists know what RATTUS RATTUS means.

New Meanings for Old   **Cycle** means a 2-wheeled vehicle to you, but it means 'things done in a particular order' to a computer manager.

Science languages are very important.

They save time.

They are understood all over the world, by people speaking many different languages of their own.

73

Your Body

You have already learnt something about the skeleton and muscles, and about the senses.

The Brain
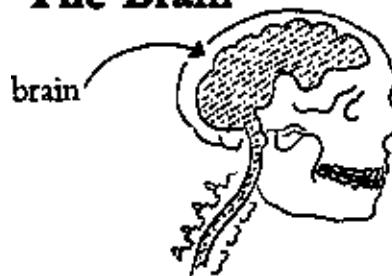
The brain is inside your head. It is protected by a hard bone cover called the skull. From the brain the nerves, tiny white thread-like things, go to every part of your body. The nerves send messages to the brain: the brain thinks, feels, remembers and controls the body.

The Heart
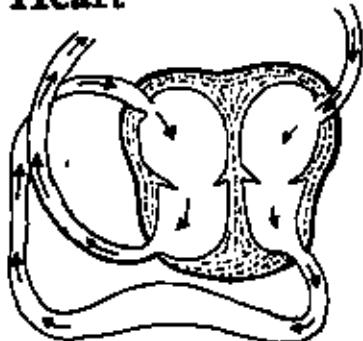
The heart is under your left breast. It pumps the blood through your body. The blood runs through arteries and veins to every part of your body. Arteries and veins are thin tubes which carry the blood. Why do we have blood? It feeds every part of our bodies, and cleans every part of our bodies at the same time.

The Lungs
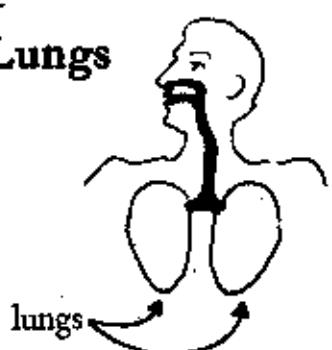
When you take breath in, your lungs expand.
The air in your lungs cleans the blood in your body, and when you breathe out, the impurities* are sent out too.

* *impurities:* things which are dirty.

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Your Body

Digestion. Whatever food you eat is taken in through your mouth. The food is broken up into small pieces by your teeth. Then it goes down a tube into your stomach. There special juices act on it so that it can be taken in by the blood. Then it passes into a very long tube — the intestines — more juices from the liver act on it — and more food is taken out of it by the blood. Anything that remains is sent out of the body through the anus.
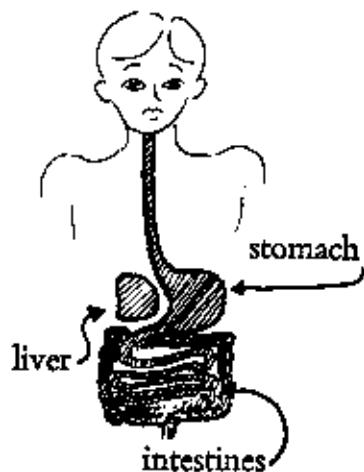
The Kidneys. The kidneys act as a filter. Some blood passes into the kidneys (you have two kidneys), and waste liquid passes through the kidneys and is passed out of the body as urine.


As you can see, the body is a most wonderful machine. It is also very complicated*: millions of cells (Do you remember what a cell is ?), hundreds of bones, muscles, veins, hairs and other things.

Some people spend a whole lifetime studying one part of the body, such as the heart or the lungs.

* *Complicated* means *difficult to understand.*

Changes
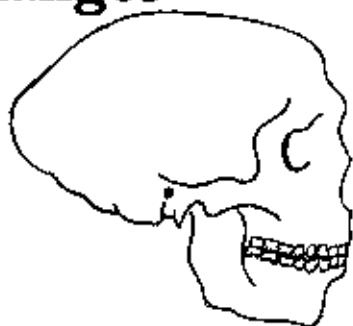
Prehistoric Man's Skull   Modern Man's Skull
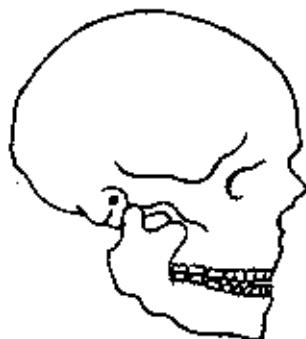
Over many thousands of years the shape of a man's skull has slowly changed.

Imagine a quick change! Imagine you are free to design a different kind of head.

What changes would you make? Draw your new head and label the parts. Write reasons for the changes you have made.

Design Features			Things to remember
eyes			
nose			
ears	number of them ?		usefulness ?
mouth			
hair	shape ?		appearance ? (beautiful ?)
shape			
teeth	size ?		Can they easily be broken ? Will
tongue			they wear out ?
throat	position ?		
brain			

Compare your drawings with other members of the class; perhaps discussion will make you want to change your design.

Analysis

Do you remember what you learnt about chemical analysis on page 71 ? That was analysis by separation. Chemists have other ways of analysing things.

Some substances (ink, for example), when they are dissolved in water, travel along a piece of paper more quickly than other substances.

The name given to this method of analysis is **paper chromatography.** *Chroma* in Greek means colour, and *graphein* means to write.

Take a piece of blotting paper about 40 cm by 5 cm. Put it on a table with a weight on it, and let it dip into a tin lid of water. Before you dip the paper into the water, put a drop of black ink on the paper, about 10 cm above the water.

What happens ? Observe, and write, and draw accurately.

What colours are used in making black ink ?

> Try more inks.
>
> Try mixed inks.
>
> Try other liquids (coffee & milk, for example) and see what happens.
>
> Observe — record — think.

77
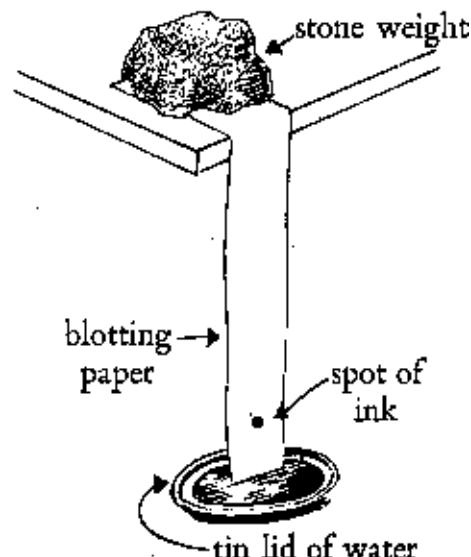
Punched Cards

Punched cards are pieces of cardboard with small holes punched in them.

They are used for
storing information.*
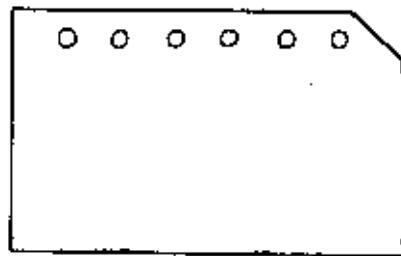
A punched card

The advantage of storing information on punched cards is that we can easily get the information we want.

An example

Take some old cigarette packets and cut them up into neat rectangles. You will need 10 cards.

Next, cut off the top right-hand corner, as shown. This is to help you sort the cards. If they fall on the ground, you can put them the right way up by making sure all the cut corners are at the top right-hand corner.
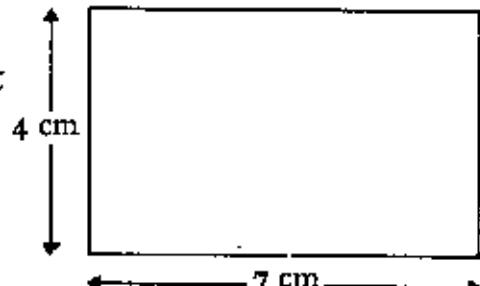
Now punch two holes at the top of each card. You can use a flattened nail; or perhaps you can borrow a punch used for punching papers before they are put in a file.

4 cm

7 cm
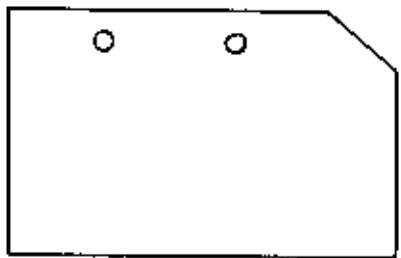
Information means knowledge.

78

Punched Cards

Make sure that all the holes coincide.* When you look through
10 cards you should see

THIS⟶   AND NOT⟶
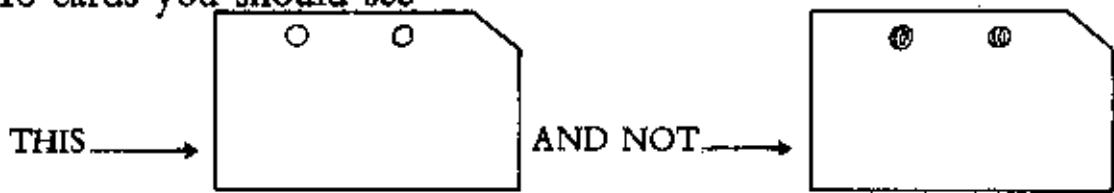
Your cards are ready. Now you have to put in the information.
Let's take 10 living things, for example:

> a bear, a swallow, a fly, a dog, a cat, an eagle, a tiger,
> a butterfly, a tortoise, a bee.

Write one name at the bottom of each card.
> If the creature flies,
> cut away the first hole.
> If it does not fly,
> cut away the second hole.

a butterfly

a dog
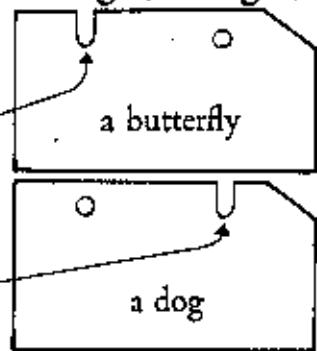
Now the information has been put in to your cards.
If you want to find all the creatures
that fly, put a matchstick into the
right-hand (or second) hole and lift.
The non-fliers will fall off, and you
will have all the flying creatures in
front of you.
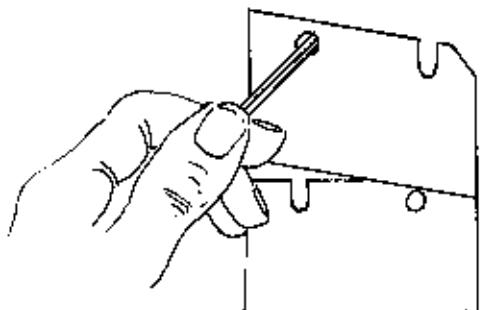
That was only an example
> to show you how punched cards work.
The more information you put in,
> the more complicated† the set of cards becomes.

Coincide means *to fit exactly on top of each other.*   † *Complicated*—see page 75.

Punched Cards: Complications

For your new set of cards you will need larger pieces, as shown, with 10 holes at the top of each.

On the cards we are going to put INFORMATION about birds.

We shall use the following headings:

1	Big	6	Black and white
2	Small	7	Mainly white
3	Long tail	8	Coloured
4	Short tail	9	Long beak
5	Mainly black	10	Short beak.
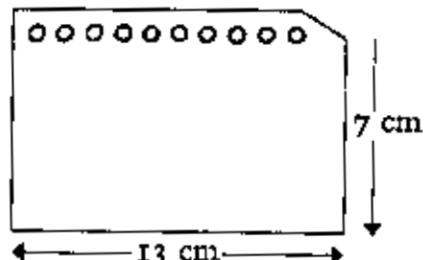
Now we shall use **a code**. A code is a way of writing information in symbols. For example,

A robin   CODE   2 4 5 10

Looking at the headings above, we can tell that the code means a robin is small (2)

has a short tail (4)

is mainly black (5)

has a short beak (10).

Code numbers for other birds would be:

Drongo	2 3 5 10	Make sure you understand
Crow	1 4 5 10	the code by writing a
Egret	1 4 7 9	description of each bird,
Eagle	1 4 8 10	i.e. changing the code
Hoopoe	2 3 8 9	into language (as we did
Pied Wagtail	2 3 6 10	with robin above).
King-fisher	2 4 8 9	

Punched Cards: More Complications

Now you can start cutting your bird cards. Remember to leave the code number holes, and only cut away the numbers which are not in the code. For example,

Code **1**   **4**   **8**   **10**   Card will be

EAGLE
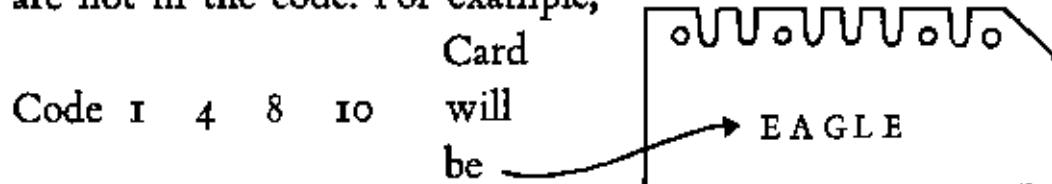
Write the name of the bird here. When all the cards have been filled with information, you will need a **master card**, like this:

Big — Small — Long tail — Short tail — Mainly black — Black & white — Mainly white — Coloured — Long beak — Short beak —
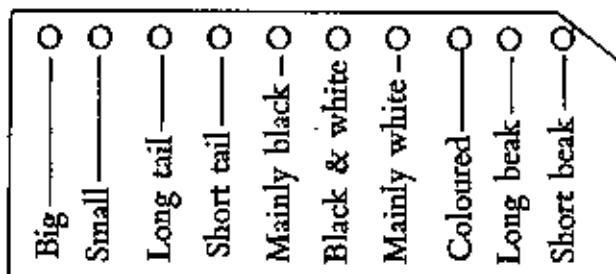
Now imagine someone who sees a small black bird with a short tail and short beak. He puts a match in hole 2 and pulls out all the cards: he puts a match in all those cards at hole 4 and so on. He finds the bird he has seen is a robin.

Add more birds to your bird-set.

Make new sets of cards—some possibilities:

      Insects—You will have to make a list of headings.

      Plants—You will have to make a list of headings.

Try to make a set of cards which will tell you the multiplication tables, e.g. 6×4 or 7×9. Write some questions about and try to answer them.

Help:

1 2 3 4 5 6 7 8 9 10

8⊬

10 9 8 7 6 5 4 3 2 1 ·
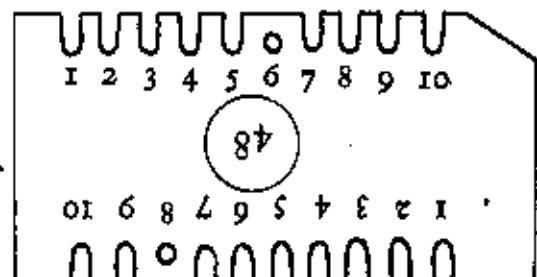
Computers

Do you know the word to *calculate* ? It means to add up, and do other things with numbers.

In the world of today many scientists need to use computers. Computers are large calculating machines, worked by electricity. They do not only deal with numbers: they deal with any information you put into them.

Calculating machines are not new. The Romans used a simple 'machine' for adding up numbers. *Calculus* in Latin means a small stone: the Romans made furrows or lines in the sand and used pebbles. The number in the picture, for example, reads 147. If they wanted to add 4, they put 4 pebbles in the right-hand row, then took out 10 and put 1 in the next row, to read 151.
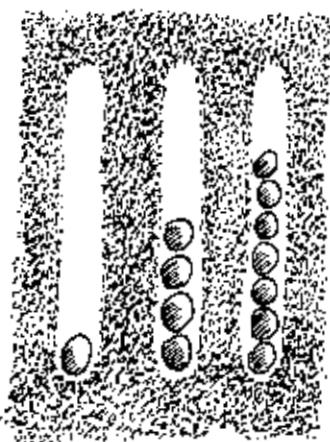
More calculating machines were made over the centuries. A simple addition machine you can make for yourself is given on pages 85-87. A multiplication machine is also given on pages 85-87.

But in the last thirty years research has made it possible to build large calculating machines (computers) which can do things in a few seconds which you and I would take years to do.

Computers

Imagine your mother cooking a chapati. The things required are flour, salt and water: also a recipe, or instructions for making a chapati. The flour, etc. goes into the store-room.[1] Your mother takes the recipe,[1] goes to the kitchen, then brings[2] the things from the store-room, does her cooking,[3] and produces a chapati.[4] Here it is in

DIAGRAM FORM

THINGS REQUIRED	
Flour Salt Water	RECIPE

STORE ROOM

KITCHEN

CHAPATI

① and ① happens at the same time; then ②, then ③ and lastly ④.
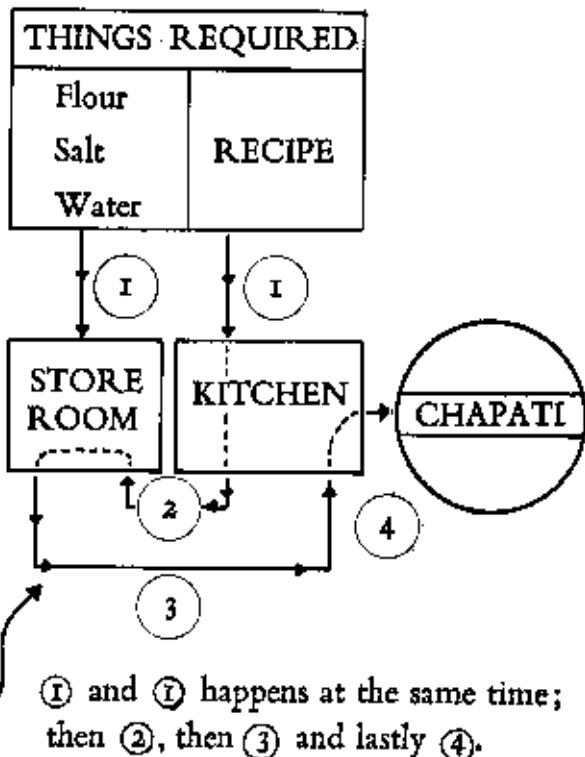
EXACTLY the same process goes on in a Computer: Instead of flour, etc. we have
**information**
(the sort of things you put on your punched cards).
Instead of recipes we have
instructions
(telling the machine what to do). The control unit takes information from the storage unit, carries out the instructions, and produces what we want, which is called OUTPUT.

INPUT	
Information	Instructions

STORAGE UNIT

CONTROL UNIT

OUTPUT

83
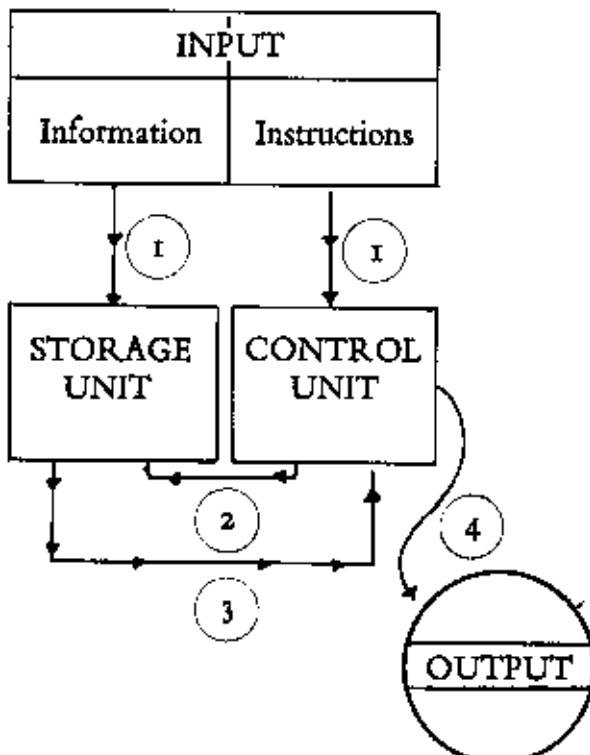
Computers

If you were lucky enough to visit a computer, you would see lots of little windows with lights going on and off.

Putting information into a computer is rather like putting information on your punched cards. If you remember, we had a description of a robin, and we coded it as 2 4 5 10.

Computers often have to change WORDS into NUMBERS.

Do you remember the Morse Code in Book 2? Here it is:

a ._	e .	i ..	m __	q __._	u .._	y _.__
b _...	f .._.	j .___	n _.	r ._.	v ..._	z __..
c _._.	g __.	k _._	o ___	s ...	w .__	
d _..	h	l ._..	p .__.	t _	x _.._	

How could you CODE the MORSE CODE in numbers? You could do it this way:

A (. —) =
B (— · · ·) =
C (— · — ·) =
} for punched cards

Or we could use numbers instead of cards. If we used 1 for ▮, and o for O above, we should get:

A	=	10	11	00	00
B	=	11	10	10	10
C	=	11	10	11	10

Try to put the whole Morse Code in ▮ and O, and then in numbers.

Then try to write your name in Number Morse Code.

My name is 11 10 10 00. 10 11 00 00. 10 10 10 11.
10 10 00 00. 11 10 10 00.

What is my name?

Computers use this kind of Code.

Calculating Machines

On page 87 you will find plans for making two calculating machines. One will do simple addition sums (which you can do already) and is only a sample of the slide rule which you will learn to make in Book V. The second one will do multiplication sums, even quite difficult ones such as 364×287, and it does not need multiplication tables to do it. If you don't yet know your multiplication tables it is just the thing for you.

The Adding Machine

Paste the top part of page 87 on to cardboard. Then cut out the base, and the two scales A and B . Stick A on to the base in the position shown on the plan. Put B below A , but do not stick it : fasten two rubber bands over the base, A and B , in the positions shown. B should be free to move away along the base, below A .

To do addition proceed as follows :

To add 8 + 9, put the 8 on B below the zero on A

The answer to the sum will be found on B below the 9.

8 below 0   Ans. 17 below 9.
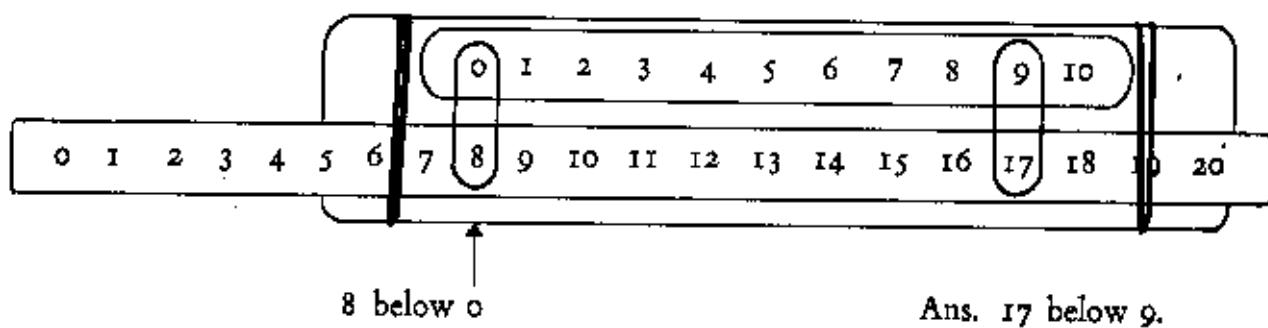
Calculating Machines

The Multiplication Machine shown on page 87 was invented by a man called Napier. Stick it on to cardboard, and cut out the 11 vertical strips as shown. The strip on the left (with a coloured square at the top) we shall call The Colour Strip: the other 10 strips we shall call Number Strips.

Multiplication

Example: 364 × 287
Put the Colour Strip on the left, then the number strip 2, then 8, then 7, like this:

First multiply by 300.
Put 2 noughts for the hundreds.
Then look at the 3 line and add diagonals.
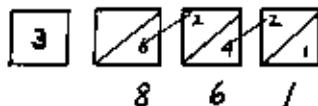
Put result here. ——— 86100

Now
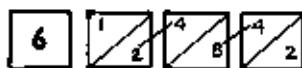
Put 1 nought for the ten and add diagonals. 1722   17220

Problems

Practise first, then try to answer these:

(a) How would you do this: 222 × 461?

(b) How would you do this: 246 × 344?

(c) How would you do this: 202 × 344?

Now

114 8   1148
Add   104468

Calculating Machines

Stick (A) here

(B) here   Do Not Stick (B)   Use rubber bands.→

(B)   Base ⟩ | 0 1 2 3 4 5 6 7 8 9 10 |←— (A)

| 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 |

Addition Machine
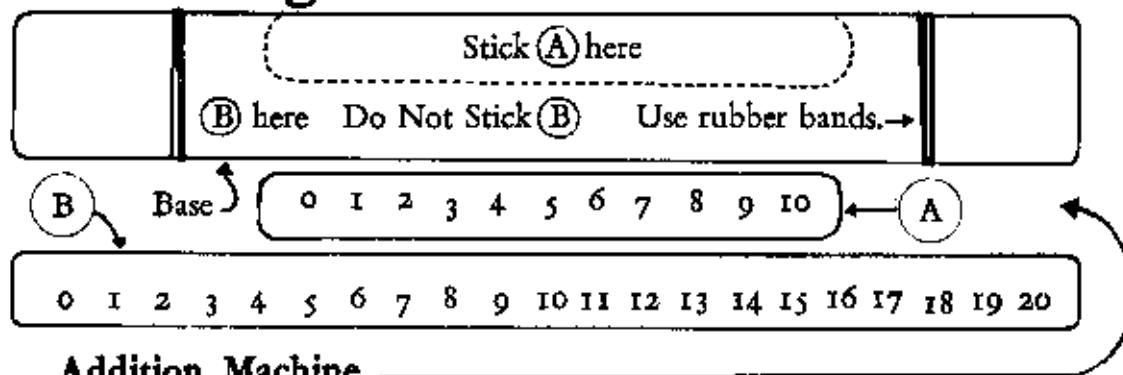
	0	1	2	3	4	5	6	7	8	9
1	0	1	2	3	4	5	6	7	8	9
2	0	2	4	6	8	10	12	14	16	18
3	0	3	6	9	12	15	18	21	24	27
4	0	4	8	12	16	20	24	28	32	36
5	0	5	10	15	20	25	30	35	40	45
6	0	6	12	18	24	30	36	42	48	54
7	0	7	14	21	28	35	42	49	56	63
8	0	8	16	24	32	40	48	56	64	72
9	0	9	18	27	36	45	54	63	72	81

Stick on to card;

    then cut along all BLUE lines (12 lines)

which will give you 11 strips.

Do not cut any black lines.

Multiplication Machine

Air Pressure

You have already learnt a lot about air pressure in Books 2 and 3. You know that

AIR EXERTS PRESSURE IN ALL DIRECTIONS.

For example, if you put your finger over a tube full of water (a drinking straw will do) there is no pressure of air coming through your finger, but the air presses up the tube and holds the water in it. Remove your finger and the air pressure at the top and the bottom is equal; the water falls out. The pressure of air is not always the same. We say it increases* or decreases.†
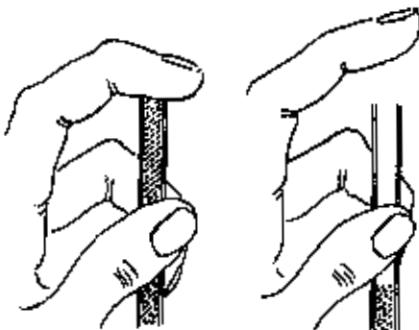
Make a Barometer

What is a barometer? It is something which shows changes in air pressure. You need an empty ink-bottle, a piece a rubber from a balloon, a piece of cork and a drinking straw. Tie the rubber tightly round the bottle, stick the cork on top, and the straw on top of that. Arrange a scale, and fix a small piece of matchstick in a blob of papier-mache on to the bottle. Keep a note of any differences that occur in the air pressure during the day.
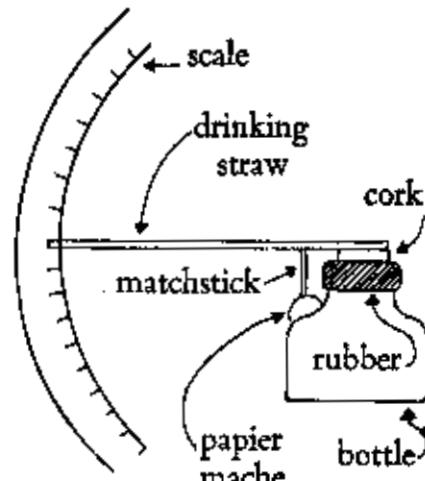
* *increases*—gets more.   † *decreases*—gets less.

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The Spinner Game

Do you remember the work you did on page 64? You had to refer to squares by using a letter and a number (e.g. 2A, 4C, etc.). The Spinner Game is played in the same way.

You need 2 spinners and 2 number boards.

The Spinners

The spinners should be of different colours, e.g. one blue and one green.
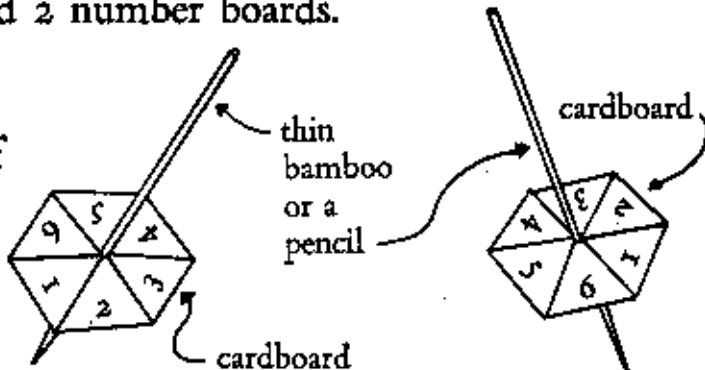
The Boards

You need 2 boards, like the one shown. They can easily be made of paper (squared maths paper is good). Write the names of the colours where shown (Blue and Green are only examples) and the numbers.

You need two players. The first player spins the two spinners, and gets, shall we say, Blue 5 and Green 4.

				BLUE			
		1	2	3	4	5	6
G	1						
R	2						
E	3						
E	4					×	
N	5						
	6						

He puts a counter on B 5 G 4 (shown by × in the illustration). Then the next player spins. If he gets on a square occupied by his opponent his score does not count. The first player to get 4 ×'s in a row wins: they can be

vertical   horizontal   or diagonal.